Mattias Lantz – Uppsala, RIKEN
in collaboration with
Lembit Sihver – Chalmers, Roanoke, Texas

UPPSALA UNIVERSITET

RIKEN NiSHiNA CENTER
RIKEN Nishina Center for Accelerator-Based Science

TEXAS A&M UNIVERSITY

ROANOKE COLLEGE

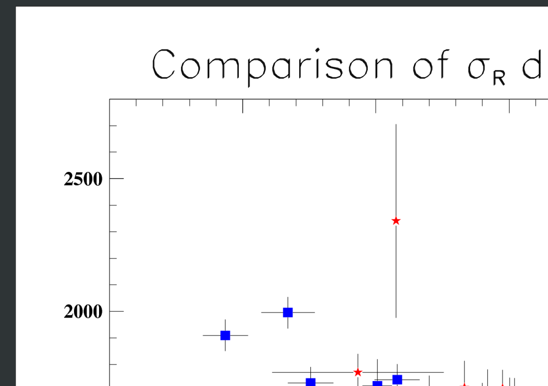
# A COMPILATION OF EXPERIMENTAL NUCLEAR DATA FOR TOTAL REACTION CROSS SECTIONS

EFNUDAT

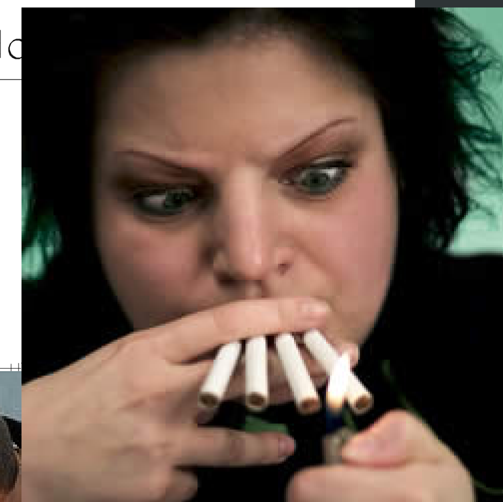
# Confessions of a nuclear data junkie

| | | | | | | |
|---|---|---|---|---|---|---|
| $^{20}$Ne | $^{24}$Mg | 2.75 | 1124 | 111 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 2.75 | 1055 | 150 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 3.00 | 1163 | 121 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 3.50 | 1339 | 153 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 4.00 | 1527 | 104 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 4.25 | 1621 | 48 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 4.25 | 1693 | 242 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 5.25 | 1780 | 102 | z | [39] |
| $^{20}$Ne | $^{24}$Mg | 2.75 | 933.4 | 133.3 | z | [217] |
| $^{20}$Ne | $^{24}$Mg | 4.25 | 1498.3 | 214.0 | z | [217] |
| $^{20}$Ne | $^{27}$Al | 30 | 2130 | 120 | | [266] |

| | | | | | | |
|---|---|---|---|---|---|---|
| $^{25}$Ne | $^{28}$Si | 44.615 | 2174 | 70 | | [422] |
| $^{25}$Ne | $^{28}$Si | 48.92 | 2145 | 22 | | [258] |
| $^{25}$Ne | $^{28}$Si | 53.808 | 2341 | 220 | | [422] |







Mattias Lantz – Uppsala University
RIKEN Nishina Center

EFNUDAT

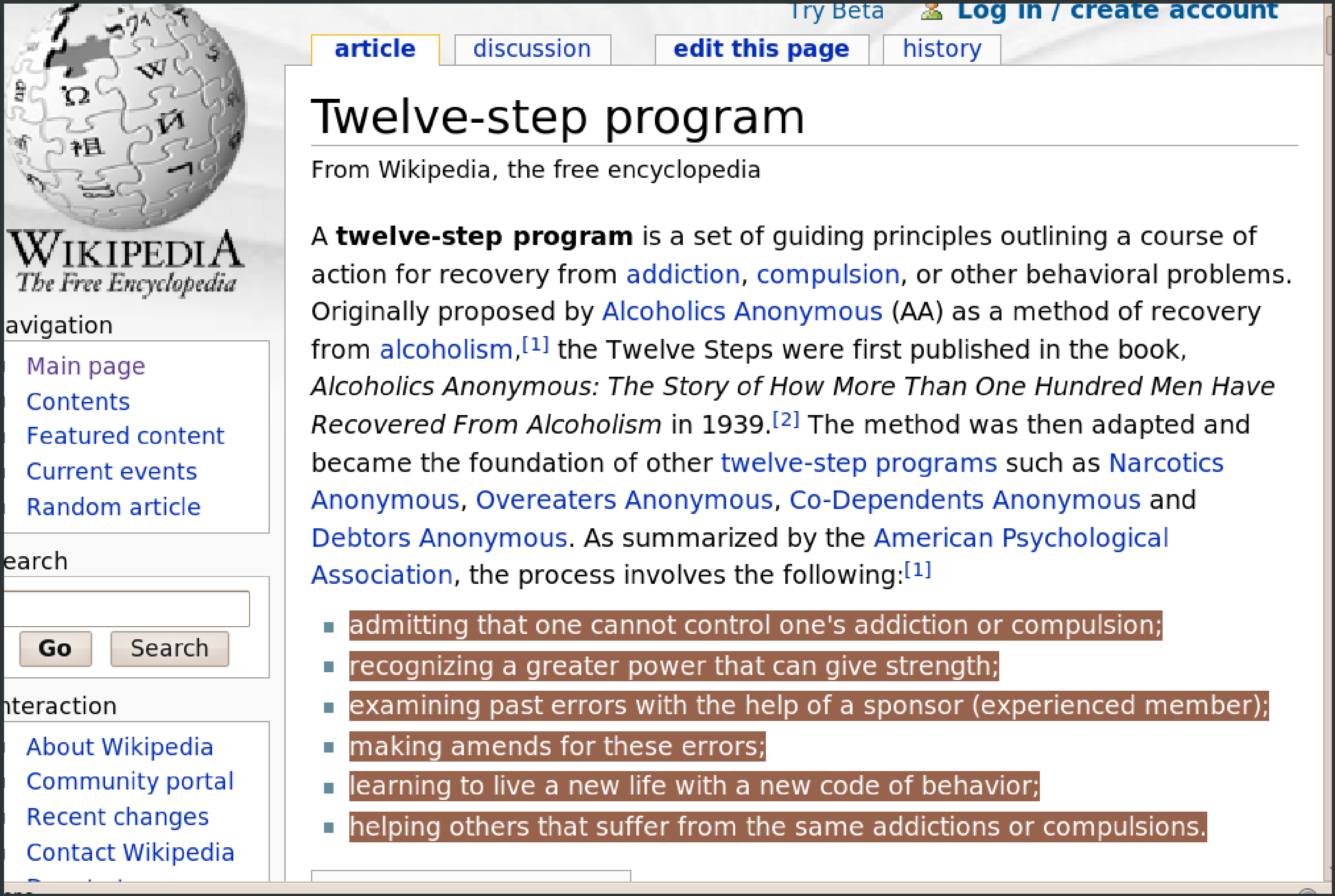
# Confessions of a nuclear data junkie

- I am on the program...
- How could I fall for it?
- Status of my addiction
- How to find more of it
- How to find the good stuff
- Positive effects from the addiction?
- How to become free from the addiction
- A call for help

EFNUDAT

# Confessions of a nuclear data junkie

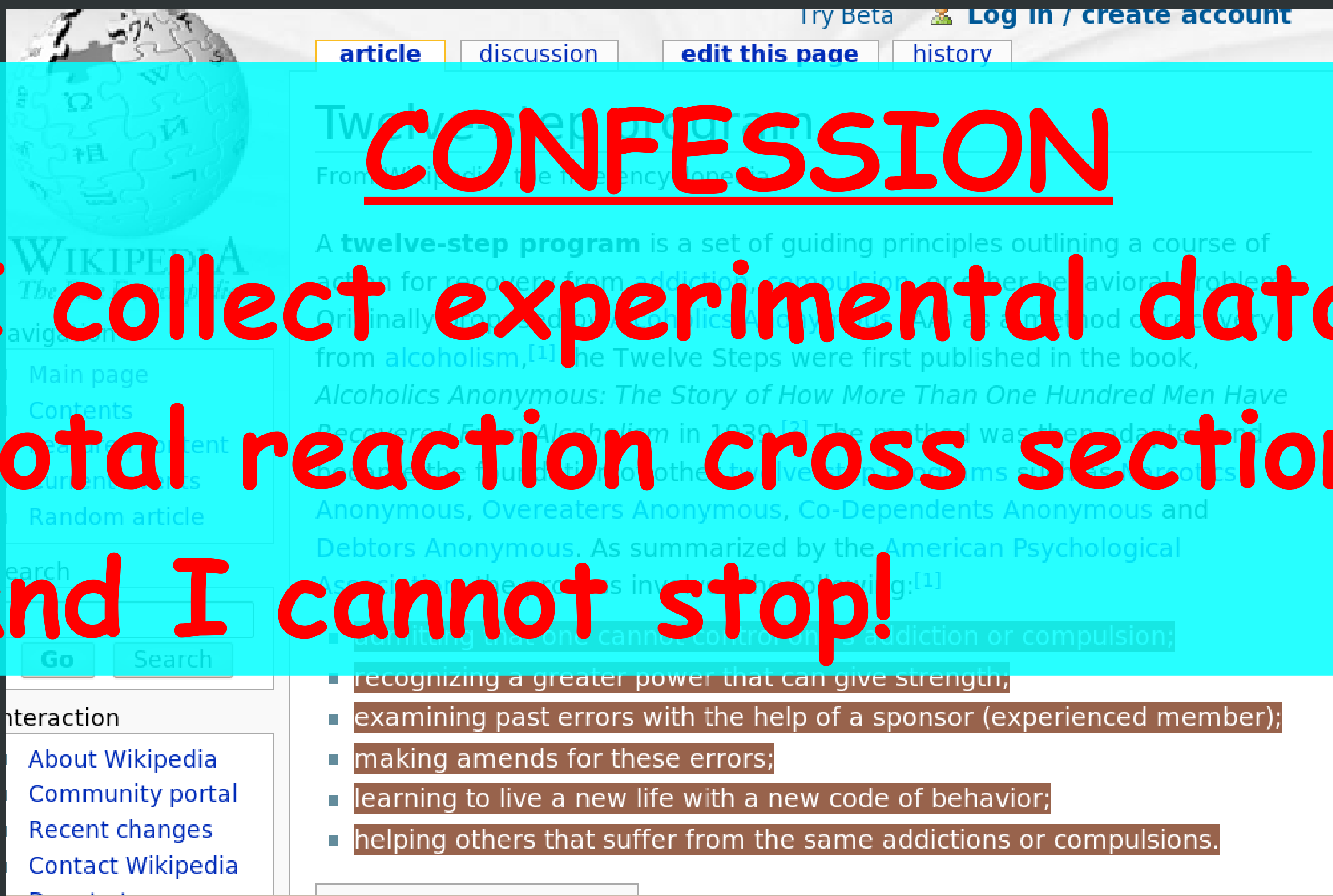
- I am on the program...




EFNUDAT

# Confessions of a nuclear data junkie

- I am on the program...




## CONFESSION

**I collect experimental data on total reaction cross sections, and I cannot stop!**

EFNUDAT

# How could I fall for it? (Background)

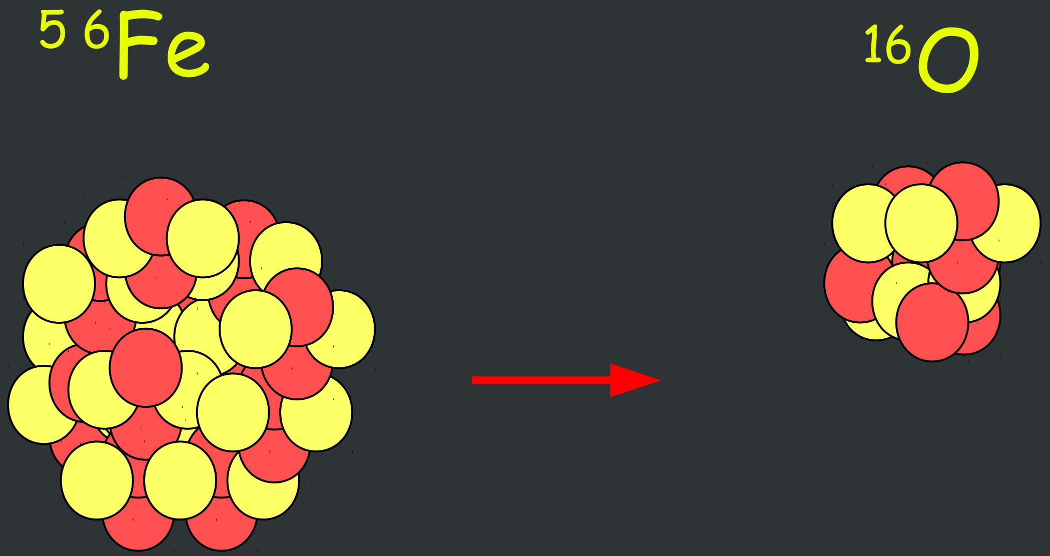
?

# How could I fall for it? (Background)

**What is the total reaction cross section?**

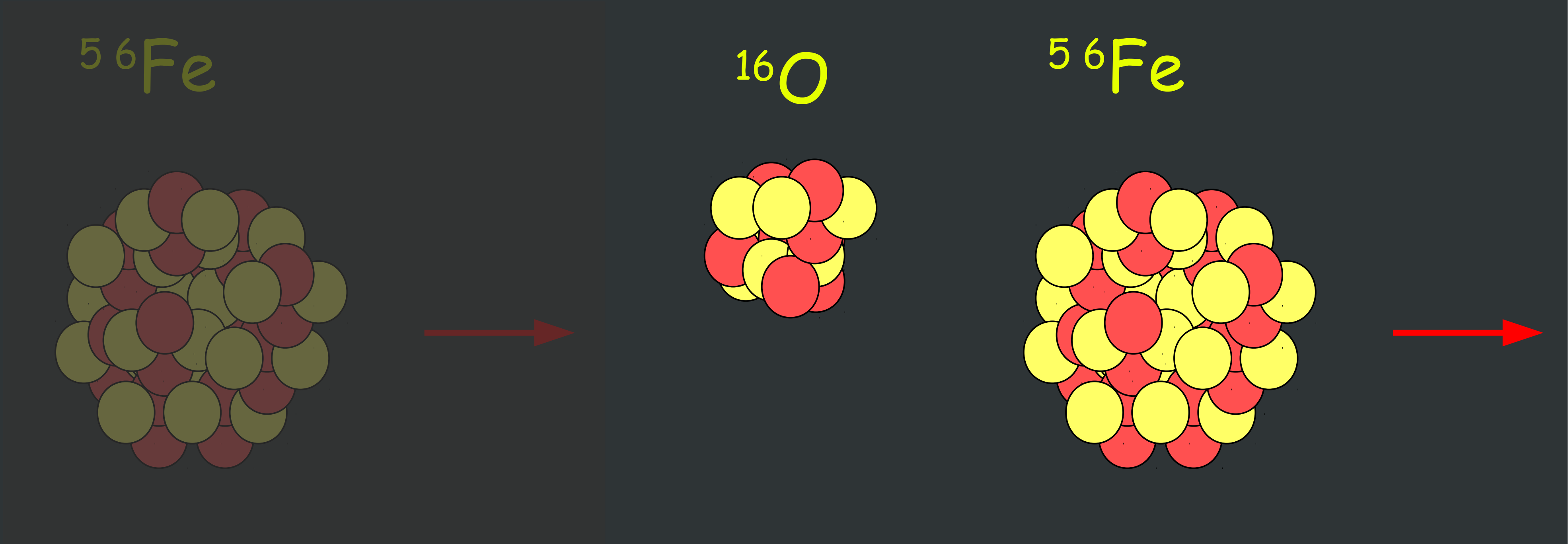
# What happens when nuclei interact?

Ex: Fe ion incident on Oxygen



# What happens when nuclei interact?

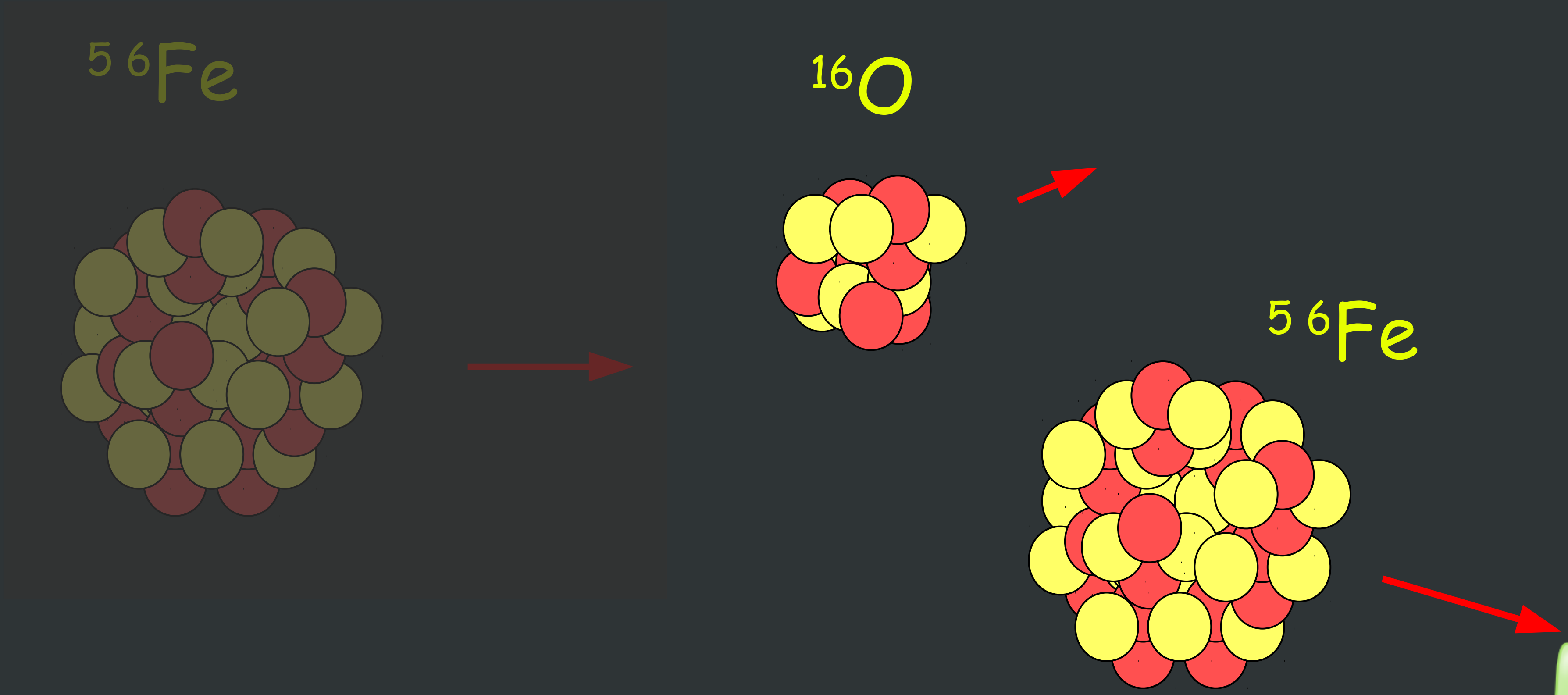
## 1: Nothing...




EFNUDAT

# What happens when nuclei interact?

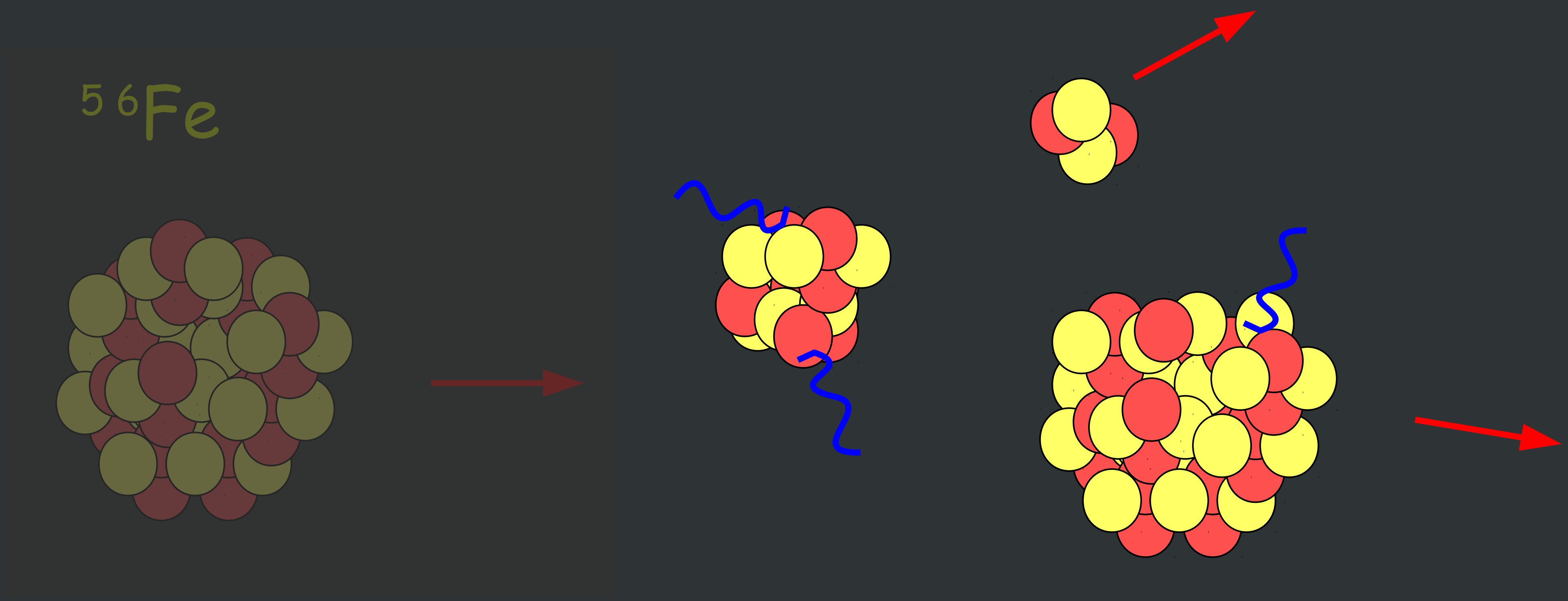
## 2: Elastic scattering $\sigma_{El}$




EFNUDAT

# What happens when nuclei interact?

## 3: Nonelastic interaction $\sigma_R$

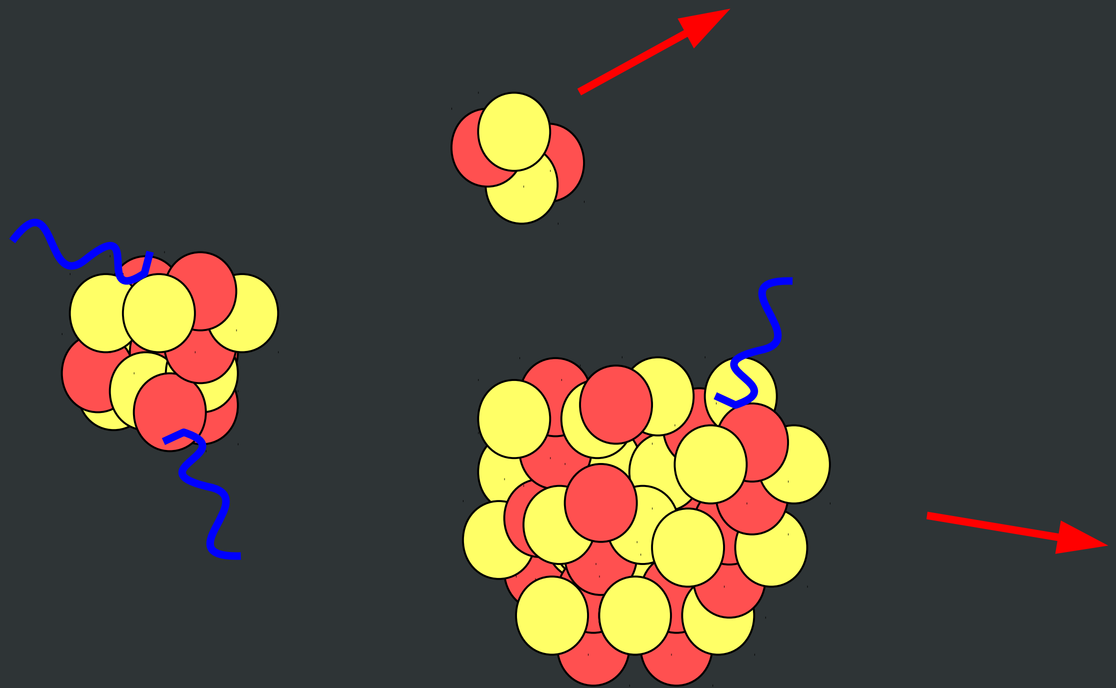



EFNUDAT

# What happens when nuclei interact?

## 3: Nonelastic interaction $\sigma_R$

Nuclear excitation
Nucleon knockout
Particle knockout
Nucleon exchange
Nucleon absorption
Spallation
Fission
Fusion
Fragmentation
Spallation
...



# What happens when nuclei interact?

## 3: Nonelastic interaction $\sigma_R$

- Nuclear excitation
- Nucleon knockout
- Particle knockout
- Nucleon exchange
- Nucleon absorption
- Spallation
- Fission
- Fusion
- Fragmentation
- Spallation
- ...

Each reaction has its individual cross section

The sum of all cross sections is the total reaction cross section

EFNUDAT

# What happens when nuclei interact?

The total reaction cross section

=

The total probability for a nonelastic reaction to occur

$$\sigma_R$$

EFNUDAT

# What happens when nuclei interact?

The total reaction cross section

=

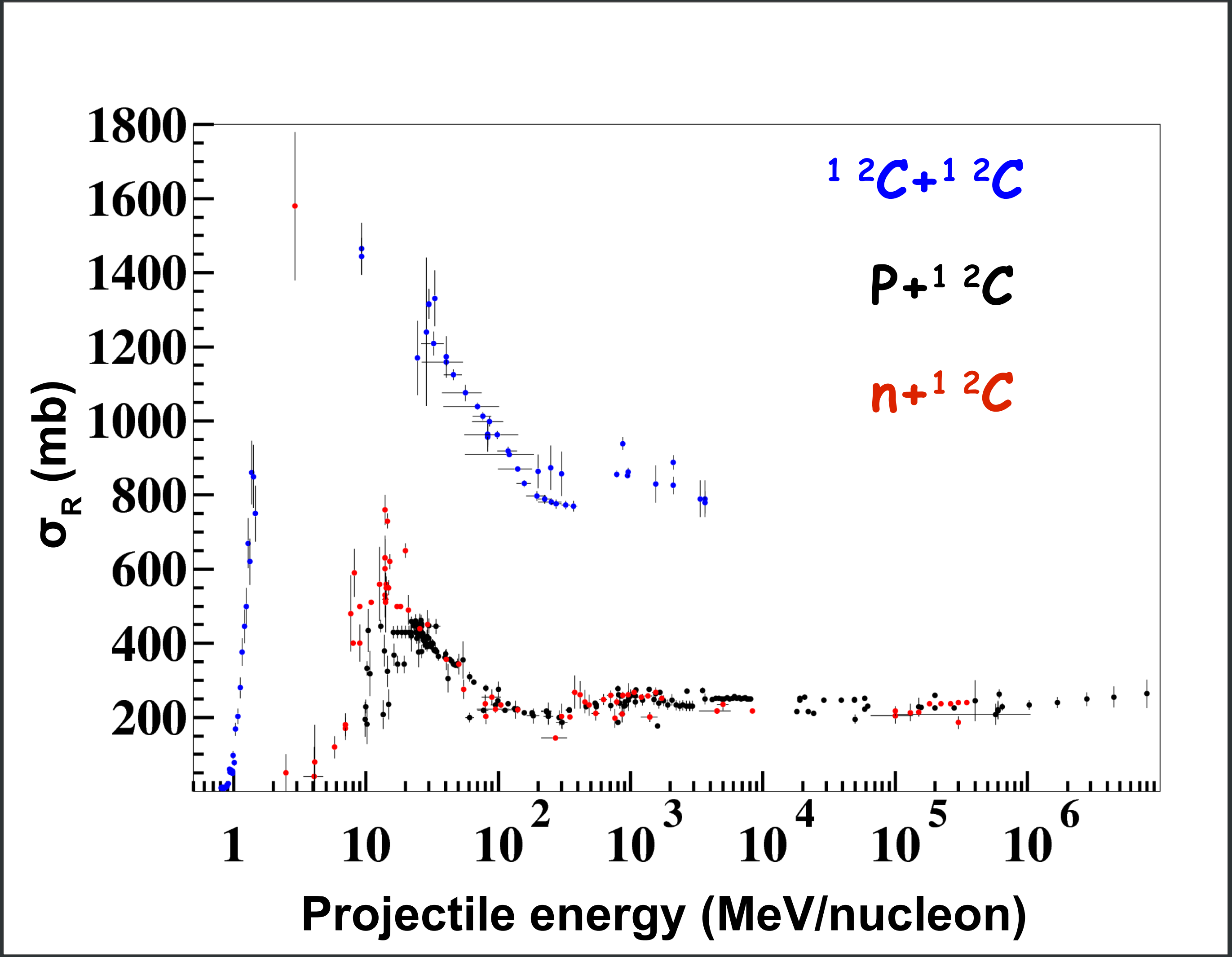
The total probability for a nonelastic reaction to occur

$$\sigma_{Tot} = \sigma_R + \sigma_{El}$$

EFNUDAT

# What happens when nuclei interact?

## $\sigma_R$ is energy dependent




EFNUDAT

# Why bother? (the road to addiction...)

## Total reaction cross sections can be used:

- To provide another constraint, besides angular distributions, in analyses of elastic scattering (Optical Model calculations...)
- To determine the sizes and matter distributions of the nuclei (exotic nuclei)

$$\sigma_R = \pi \cdot R_0^2 = \pi \cdot r_0^2 \left( A_P^{1/3} + A_T^{1/3} \right)^2$$

EFNUDAT

# Why bother? (the road to addiction…)

Total reaction cross sections can be used:

- In a number of applications:
  - Radiation cancer treatment and dosimetry
  - Space radiation shielding and dosimetry
  - Cosmic radiation effects during interacting with matter (SEE/SEU)
  - Astrophysics (nucleosynthesis)
  - Transmutation of nuclear waste
  - Energy conversion

EFNUDAT

# Why bother? (the road to addiction...)

Total reaction cross sections **are** used:

- In complex Monte Carlo codes
  **(FLUKA, GEANT, MCNPX, PHITS, ...):**
  - Determine mean-free path before the first interaction in matter
  - Scaling factor for specific reactions **(p,n), (p,2pn), (p,α), ...**

EFNUDAT

# Why bother? (the road to addiction...)

A number of compilations available:

- Protons – Bauhoff (1986) → Carlson (1996), Barashenkov (1993)
- Exotic nuclei – Ozawa *et al.* (2001)
- Data bases
  - EXFOR
  - LANL (neutrons)

# Why bother? (the road to addiction…)

A number of compilations available:

- Protons – Bauhoff (1986) → Carlson (1996), Barashenkov (1993)

  **E < 1 GeV**
- Exotic nuclei – Ozawa *et al.* (2001)
- Data bases
  - EXFOR
  - LANL (neutrons)

EFNUDAT

# Why bother? (the road to addiction…)

A number of compilations available:

- Protons – Bauhoff (1986) → Carlson (1996),
  Barashenkov (1993)

**E < 1 GeV**

**Inconsistencies...**

- Exotic nuclei – Ozawa *et al.* (2001)
- Data bases
  - EXFOR
  - LANL (neutrons)

EFNUDAT

# Why bother? (the road to addiction…)

A number of compilations available:

- Protons – Bauhoff (1986) → Carlson (1996), Barashenkov (1993)
  - **E < 1 GeV**
  - **Inconsistencies...**
- Exotic nuclei – *Ozawa et al.* (2001)
  - **Limited nuclei**
- Data bases
  - EXFOR
  - LANL (neutrons)

EFNUDAT

# Why bother? (the road to addiction...)

A number of compilations available:

- Protons – Bauhoff (1986) → Carlson (1996), Barashenkov (1993)

  **E < 1 GeV**

  **Inconsistencies...**

- Exotic nuclei – *Ozawa et al*

  **Limited nuclei**

- Data bases
  - EXFOR
  - LANL (neutrons)

**Very valuable resource, but limited, and somewhat complicated to use. Also some inconsistencies.**

EFNUDAT

# Why bother? (the road to addiction…)

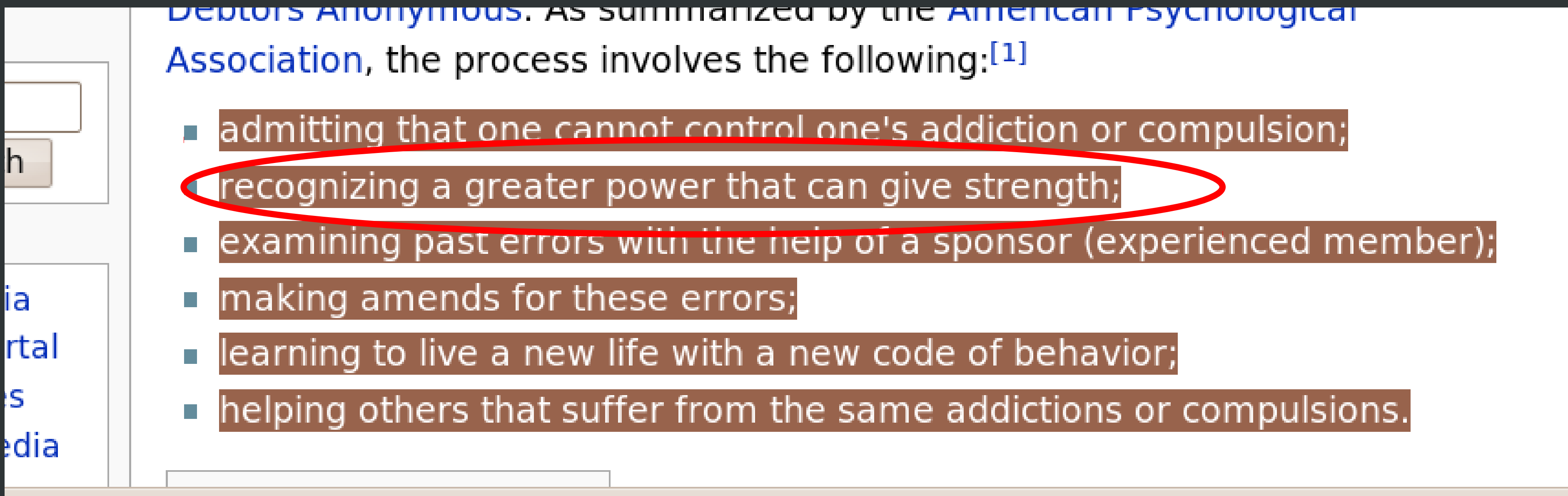
Personal motivation:

- Need data for development of models, have collected (and measured) data since ~2000
- Noticed that some model makers are “lazy” or are not using the available data in a correct way
- Noticed that most model makers are not aware of all the available data (hard work!)

EFNUDAT

# Why bother? (the road to addiction…)

## Personal motivation:


Debtors Anonymous. As summarized by the American Psychological Association, the process involves the following:[1]

- admitting that one cannot control one's addiction or compulsion;
- recognizing a greater power that can give strength;
- examining past errors with the help of a sponsor (experienced member);
- making amends for these errors;
- learning to live a new life with a new code of behavior;
- helping others that suffer from the same addictions or compulsions.

- Realized in 2009: I have a large collection of experimental data that many people seem to be unaware of, why not publish it?

EFNUDAT

# Why bother? (the road to addiction...)

Personal motivation:

- 2009: Merged Lantz & Sihver data bases into one, following up references and citations
- Goal:
  - Submit for publication before end of 2010 (probably too optimistic)
  - Make data easily available for inclusion in EXFOR (have dialogue with IAEA)
  - (get done and move on with research...)

EFNUDAT

# Status of my addiction

20 July 2010: 55 pages of tables, ~550 refs.

- $\sigma_R$ data for:
  - p+A (~2100 data points)
  - n+A (~1100)
  - A+A (2400)
- Also other data of similar interest
  - $\sigma_I$ A+A (~400)
  - $\sigma_{CC}$ A+A (~900)
  - $\sigma_{Tot}$ p+A, A+A (~300)

EFNUDAT

# Status of my addiction

## 20 July 2010: 55 pages of tables, ~550 refs.

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{12}C$ | 9.33 | | 1465 | 70 | | [168] |
| $^{12}C$ | $^{12}C$ | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}C$ | $^{12}C$ | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}C$ | $^{12}C$ | 28.7 | | 1240 | 200 | z | [364] |
| $^{12}C$ | $^{12}C$ | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 30 | | 1316 | 40 | | [329] |
| $^{12}C$ | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}C$ | $^{12}C$ | 33.1 | | 1331 | 75 | | [563] |
| $^{12}C$ | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}C$ | $^{12}C$ | 40.7 | | 1173 | 56 | | [223] |
| $^{12}C$ | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}C$ | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}C$ | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}C$ | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}C$ | $^{12}C$ | 83 | | 957 | 39 | | [564] |
| $^{12}C$ | $^{12}C$ | 83 | | 960 | 30 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 83 | | 965 | 30 | | [329] |
| $^{12}C$ | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}C$ | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}C$ | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}C$ | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}C$ | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}C$ | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}C$ | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}C$ | $^{12}C$ | 200 | | 864 | 45 | | [329] |
| $^{12}C$ | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}C$ | $^{12}C$ | 250 | | 873 | 60 | | [329] |
| $^{12}C$ | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}C$ | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

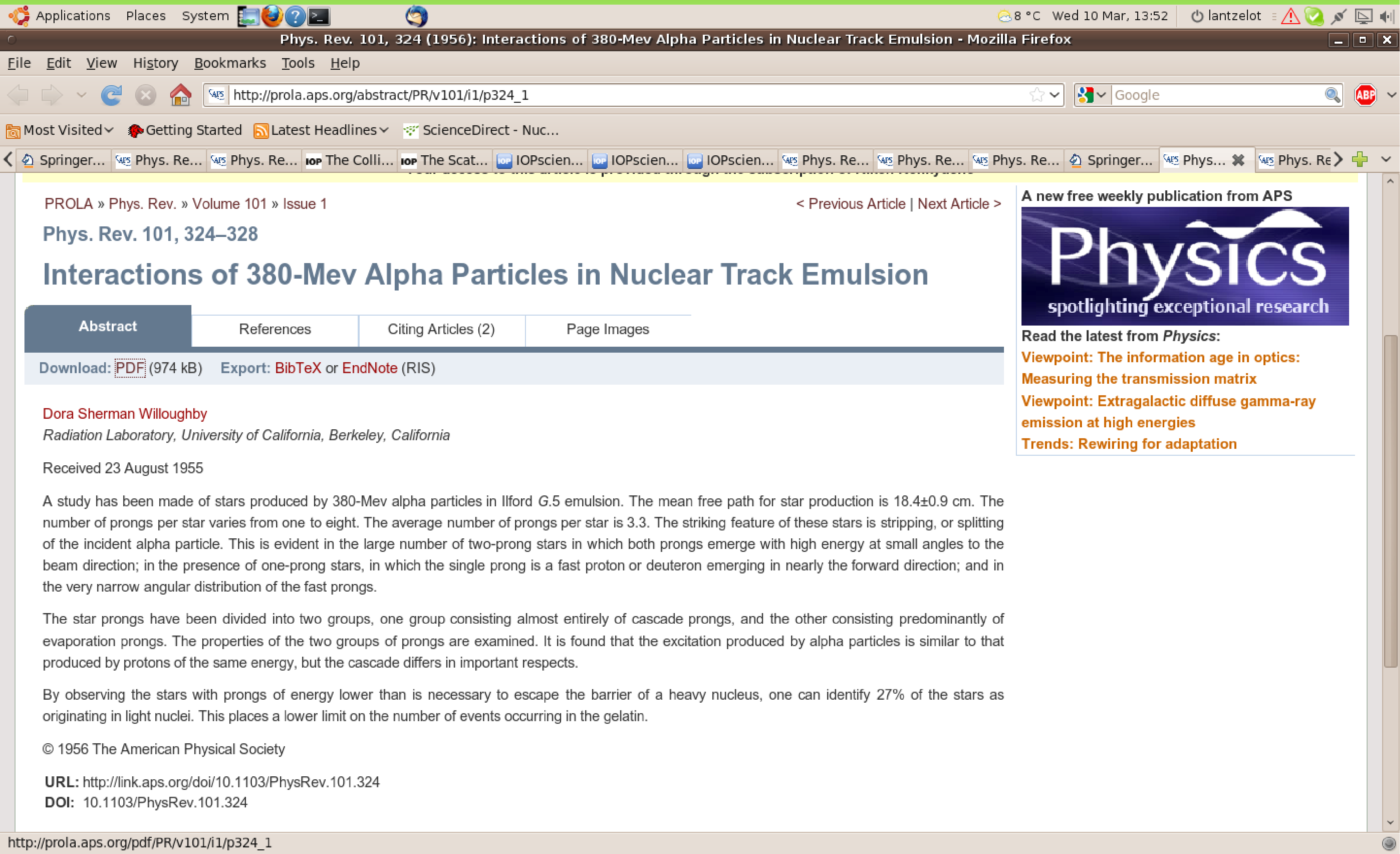
| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{28}Si$ | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}C$ | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}C$ | Si | 39 | 5 | 1555 | 45 | r | [534] |
| $^{12}C$ | Si | 70? | | | | r | [347] |
| $^{12}C$ | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}C$ | $^{32}S$ | 2100 | | 1250 | 51 | em | [355] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1550 | 60 | | [328] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1510 | 60 | | [329] |
| $^{12}C$ | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}C$ | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}C$ | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 30 | | 2185 | 140 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1815 | 100 | | [328] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1776 | 100 | | [329] |
| $^{12}C$ | $^{56}Fe$ | 83 | | 1810 | 100 | | [328] |
| $^{12}C$ | $^{56}Fe$ | 83 | | 1791 | 150 | | [329] |
| $^{12}C$ | $^{57}Fe$ | 30 | | 2296 | 160 | | [329] |
| $^{12}C$ | $^{57}Fe$ | 83 | | 1820 | 80 | | [328] |
| $^{12}C$ | $^{57}Fe$ | 83 | | 1867 | 100 | | [329] |
| $^{12}C$ | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}C$ | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}C$ | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}C$ | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}C$ | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}C$ | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}C$ | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}C$ | Zn | 200 | | 1747 | 110 | | [329] |

# How to find more of it

- Easy methods
    - Key word search: ”total reaction cross section”
    - Author search
    - PACS numbers search
    - Check reference lists carefully
- Difficult methods
    - Find ”strange” references (technical reports, conference proceedings, journals in Russian, Chinese...)
    - Talk with people
    - Use ”Citing articles” function

EFNUDAT

# How to find more of it



Phys. Rev. 101, 324 (1956): Interactions of 380-Mev Alpha Particles in Nuclear Track Emulsion - Mozilla Firefox

http://prola.aps.org/abstract/PR/v101/i1/p324_1

PROLA » Phys. Rev. » Volume 101 » Issue 1

< Previous Article | Next Article >


Phys. Rev. 101, 324–328


## Interactions of 380-Mev Alpha Particles in Nuclear Track Emulsion

Abstract | References | Citing Articles (2) | Page Images

Download: PDF (974 kB) Export: BibTeX or EndNote (RIS)


Dora Sherman Willoughby

*Radiation Laboratory, University of California, Berkeley, California*



Received 23 August 1955



A study has been made of stars produced by 380-Mev alpha particles in Ilford *G*.5 emulsion. The mean free path for star production is 18.4±0.9 cm. The number of prongs per star varies from one to eight. The average number of prongs per star is 3.3. The striking feature of these stars is stripping, or splitting of the incident alpha particle. This is evident in the large number of two-prong stars in which both prongs emerge with high energy at small angles to the beam direction; in the presence of one-prong stars, in which the single prong is a fast proton or deuteron emerging in nearly the forward direction; and in the very narrow angular distribution of the fast prongs.

The star prongs have been divided into two groups, one group consisting almost entirely of cascade prongs, and the other consisting predominantly of evaporation prongs. The properties of the two groups of prongs are examined. It is found that the excitation produced by alpha particles is similar to that produced by protons of the same energy, but the cascade differs in important respects.

By observing the stars with prongs of energy lower than is necessary to escape the barrier of a heavy nucleus, one can identify 27% of the stars as originating in light nuclei. This places a lower limit on the number of events occurring in the gelatin.





URL: http://link.aps.org/doi/10.1103/PhysRev.101.324

DOI: 10.1103/PhysRev.101.324

# How to find more of it

# How to find more of it

# How to find the good stuff

## We are in a stage of quality control...

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{12}$C | 9.33 | | 1465 | 70 | | [168] |
| $^{12}$C | $^{12}$C | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}$C | $^{12}$C | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}$C | $^{12}$C | 28.7 | | 1240 | 200 | z | [364] |
| $^{12}$C | $^{12}$C | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}$C | $^{12}$C | 30 | | 1316 | 40 | | [329] |
| $^{12}$C | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}$C | $^{12}$C | 33.1 | | 1331 | 75 | | [563] |
| $^{12}$C | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}$C | $^{12}$C | 40.7 | | 1173 | 56 | | [223] |
| $^{12}$C | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}$C | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}$C | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}$C | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}$C | $^{12}$C | 83 | | 957 | 39 | | [564] |
| $^{12}$C | $^{12}$C | 83 | | 960 | 30 | | [430, 328] |
| $^{12}$C | $^{12}$C | 83 | | 965 | 30 | | [329] |
| $^{12}$C | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}$C | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}$C | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}$C | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}$C | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}$C | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}$C | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}$C | $^{12}$C | 200 | | 864 | 45 | | [329] |
| $^{12}$C | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}$C | $^{12}$C | 250 | | 873 | 60 | | [329] |
| $^{12}$C | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}$C | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{28}$Si | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}$C | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}$C | Si | 39 | 5 | 1555 | 45 | r | [534] |
| $^{12}$C | Si | 70? | | | | r | [347] |
| $^{12}$C | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}$C | $^{32}$S | 2100 | | 1250 | 51 | em | [355] |
| $^{12}$C | $^{40}$Ca | 83 | | 1550 | 60 | | [328] |
| $^{12}$C | $^{40}$Ca | 83 | | 1510 | 60 | | [329] |
| $^{12}$C | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}$C | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}$C | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}$C | $^{54}$Fe | 30 | | 2185 | 140 | | [329] |
| $^{12}$C | $^{54}$Fe | 83 | | 1815 | 100 | | [328] |
| $^{12}$C | $^{54}$Fe | 83 | | 1776 | 100 | | [329] |
| $^{12}$C | $^{56}$Fe | 83 | | 1810 | 100 | | [328] |
| $^{12}$C | $^{56}$Fe | 83 | | 1791 | 150 | | [329] |
| $^{12}$C | $^{57}$Fe | 30 | | 2296 | 160 | | [329] |
| $^{12}$C | $^{57}$Fe | 83 | | 1820 | 80 | | [328] |
| $^{12}$C | $^{57}$Fe | 83 | | 1867 | 100 | | [329] |
| $^{12}$C | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}$C | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}$C | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}$C | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}$C | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}$C | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}$C | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}$C | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}$C | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}$C | Zn | 200 | | 1747 | 110 | | [329] |

# How to find the good stuff

## We are in a stage of quality control...

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{12}$C | 9.33 | | 1465 | 70 | | [168] |
| $^{12}$C | $^{12}$C | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}$C | $^{12}$C | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}$C | $^{12}$C | 28.7 | | [illegible] | [illegible] | z | [illegible] |
| $^{12}$C | $^{12}$C | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}$C | $^{12}$C | 30 | | 1316 | 40 | | [329] |
| $^{12}$C | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}$C | $^{12}$C | 33.1 | | 1331 | 75 | | [563] |
| $^{12}$C | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}$C | $^{12}$C | 40.7 | | 1173 | 56 | | [223] |
| $^{12}$C | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}$C | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}$C | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}$C | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}$C | $^{12}$C | 83 | | 957 | 39 | | [564] |
| $^{12}$C | $^{12}$C | 83 | | 960 | 30 | | [430, 328] |
| $^{12}$C | $^{12}$C | 83 | | 965 | 30 | | [329] |
| $^{12}$C | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}$C | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}$C | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}$C | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}$C | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}$C | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}$C | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}$C | $^{12}$C | 200 | | 864 | 45 | | [329] |
| $^{12}$C | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}$C | $^{12}$C | 250 | | 873 | 60 | | [329] |
| $^{12}$C | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}$C | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{28}$Si | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}$C | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}$C | Si | 39 | 5 | 1555 | 45 | r | [534] |
| [illegible] | Si | 70? | | | | r | [347] |
| $^{12}$C | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}$C | $^{32}$S | 2100 | | 1250 | 51 | em | [355] |
| $^{12}$C | $^{40}$Ca | 83 | | 1550 | 60 | | [328] |
| $^{12}$C | $^{40}$Ca | 83 | | 1510 | 60 | | [329] |
| $^{12}$C | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}$C | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}$C | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}$C | $^{54}$Fe | 30 | | 2185 | 140 | | [329] |
| $^{12}$C | $^{54}$Fe | 83 | | 1815 | 100 | | [328] |
| $^{12}$C | $^{54}$Fe | 83 | | 1776 | 100 | | [329] |
| $^{12}$C | $^{56}$Fe | 83 | | 1810 | 100 | | [328] |
| $^{12}$C | $^{56}$Fe | 83 | | 1791 | 150 | | [329] |
| $^{12}$C | $^{57}$Fe | 30 | | 2296 | 160 | | [329] |
| $^{12}$C | $^{57}$Fe | 83 | | 1820 | 80 | | [328] |
| $^{12}$C | $^{57}$Fe | 83 | | 1867 | 100 | | [329] |
| $^{12}$C | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}$C | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}$C | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}$C | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}$C | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}$C | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}$C | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}$C | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}$C | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}$C | Zn | 200 | | 1747 | 110 | | [329] |

Isotopically enriched
or natural composition?

# How to find the good stuff

## We are in a stage of quality control...

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{12}C$ | 9.33 | | 1465 | 70 | | [168] |
| $^{12}C$ | $^{12}C$ | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}C$ | $^{12}C$ | 24.42 | | [illegible] | $^{+170}_{-100}$ | z | [472] |
| $^{12}C$ | $^{12}C$ | 28.7 | | [illegible] | 200 | [illegible] | [illegible] |
| $^{12}C$ | $^{12}C$ | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 30 | | [illegible] | [illegible] | | [illegible] |
| $^{12}C$ | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}C$ | $^{12}C$ | 33.1 | | 1331 | 75 | | [563] |
| $^{12}C$ | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}C$ | $^{12}C$ | 40.7 | | 1173 | 56 | | [223] |
| $^{12}C$ | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}C$ | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}C$ | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}C$ | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}C$ | $^{12}C$ | 83 | | 957 | 39 | | [564] |
| $^{12}C$ | $^{12}C$ | 83 | | 960 | 30 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 83 | | 965 | 30 | | [329] |
| $^{12}C$ | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}C$ | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}C$ | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}C$ | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}C$ | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}C$ | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}C$ | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}C$ | $^{12}C$ | 200 | | 864 | 45 | | [329] |
| $^{12}C$ | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}C$ | $^{12}C$ | 250 | | 873 | 60 | | [329] |
| $^{12}C$ | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}C$ | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{28}Si$ | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}C$ | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}C$ | Si | 39 | 5 | 1555 | 45 | r | [534] |
| $^{12}C$ | Si | 70? | | | | r | [347] |
| $^{12}C$ | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}C$ | $^{32}S$ | 2100 | | 1250 | 51 | em | [355] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1550 | 60 | | [328] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1510 | 60 | | [329] |
| $^{12}C$ | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}C$ | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}C$ | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 30 | | 2185 | 140 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1815 | 100 | | [328] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1776 | 100 | | [329] |
| $^{12}C$ | $^{56}Fe$ | 83 | | 1810 | 100 | | [328] |
| $^{12}C$ | $^{56}Fe$ | 83 | | 1791 | 150 | | [329] |
| $^{12}C$ | $^{57}Fe$ | 30 | | 2296 | 160 | | [329] |
| $^{12}C$ | $^{57}Fe$ | 83 | | 1820 | 80 | | [328] |
| $^{12}C$ | $^{57}Fe$ | 83 | | 1867 | 100 | | [329] |
| $^{12}C$ | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}C$ | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}C$ | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}C$ | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}C$ | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}C$ | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}C$ | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}C$ | Zn | 200 | | 1747 | 110 | | [329] |

Which energy?

No errors given

# How to find the good stuff

## We are in a stage of quality control...

s = Sum of Differences method

em = emulsion technique

Trustworthy experimental methods?

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{12}$C | 9.33 | | 1465 | 70 | | [168] |
| $^{12}$C | $^{12}$C | 9.33 | | [illegible] | [illegible] | | [illegible] |
| $^{12}$C | $^{12}$C | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}$C | $^{12}$C | 28.7 | | 1240 | 200 | z | [364] |
| $^{12}$C | $^{12}$C | 30 | | [illegible] | [illegible] | | [430, 328] |
| $^{12}$C | $^{12}$C | 30 | | 1316 | 40 | | [329] |
| $^{12}$C | C | 32.5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $^{12}$C | $^{12}$C | 33.1 | | 1331 | 75 | | [563] |
| $^{12}$C | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}$C | $^{12}$C | 40.7 | | 1173 | 56 | | [223] |
| $^{12}$C | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}$C | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}$C | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}$C | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}$C | $^{12}$C | 83 | | 957 | 39 | | [564] |
| $^{12}$C | $^{12}$C | 83 | | 960 | 30 | | [430, 328] |
| $^{12}$C | $^{12}$C | 83 | | 965 | 30 | | [329] |
| $^{12}$C | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}$C | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}$C | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}$C | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}$C | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}$C | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}$C | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}$C | $^{12}$C | 200 | | 864 | 45 | | [329] |
| $^{12}$C | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}$C | $^{12}$C | 250 | | 873 | 60 | | [329] |
| $^{12}$C | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}$C | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{28}$Si | 5.42 | | 1440 | 60 | s | [557] |
| [illegible] | Si | [illegible] | [illegible] | 1700 | 40 | r | [534] |
| $^{12}$C | Si | 39 | 5 | 1555 | 45 | r | [534] |
| [illegible] | Si | 70? | | | | r | [347] |
| [illegible] | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}$C | $^{32}$S | 2100 | | 1250 | 51 | em | [355] |
| [illegible] | [illegible] | [illegible] | | [illegible] | 60 | | [328] |
| $^{12}$C | $^{40}$Ca | 83 | | 1510 | 60 | | [329] |
| $^{12}$C | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}$C | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}$C | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}$C | $^{54}$Fe | 30 | | 2185 | 140 | | [329] |
| $^{12}$C | $^{54}$Fe | 83 | | 1815 | 100 | | [328] |
| $^{12}$C | $^{54}$Fe | 83 | | 1776 | 100 | | [329] |
| $^{12}$C | $^{56}$Fe | 83 | | 1810 | 100 | | [328] |
| $^{12}$C | $^{56}$Fe | 83 | | 1791 | 150 | | [329] |
| $^{12}$C | $^{57}$Fe | 30 | | 2296 | 160 | | [329] |
| $^{12}$C | $^{57}$Fe | 83 | | 1820 | 80 | | [328] |
| $^{12}$C | $^{57}$Fe | 83 | | 1867 | 100 | | [329] |
| $^{12}$C | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}$C | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}$C | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}$C | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}$C | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}$C | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}$C | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}$C | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}$C | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}$C | Zn | 200 | | 1747 | 110 | | [329] |

# How to find the good stuff

## We are in a stage of quality control...

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{12}C$ | 9.33 | | 1465 | 70 | | [168] |
| $^{12}C$ | $^{12}C$ | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}C$ | $^{12}C$ | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}C$ | $^{12}C$ | 28.7 | | 1240 | 200 | z | [364] |
| $^{12}C$ | $^{12}C$ | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 30 | | 1316 | 40 | | [329] |
| $^{12}C$ | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}C$ | $^{12}C$ | 33.1 | | 1331 | 75 | | [563] |
| $^{12}C$ | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}C$ | $^{12}C$ | 40.7 | | 1173 | 56 | | [223] |
| $^{12}C$ | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}C$ | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}C$ | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}C$ | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}C$ | $^{12}C$ | 83 | | 957 | 39 | | [illegible] |
| $^{12}C$ | $^{12}C$ | 83 | | 960 | 30 | | [430, 328] |
| $^{12}C$ | $^{12}C$ | 83 | | 965 | 30 | | [329] |
| $^{12}C$ | C | 86.3 | 22.8 | 998 | 13 | x | [illegible] |
| $^{12}C$ | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}C$ | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}C$ | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}C$ | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}C$ | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}C$ | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}C$ | $^{12}C$ | 200 | | 864 | 45 | | [329] |
| $^{12}C$ | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}C$ | $^{12}C$ | 250 | | 873 | 60 | | [329] |
| $^{12}C$ | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}C$ | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}C$ | $^{28}Si$ | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}C$ | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}C$ | Si | 39 | 5 | 1555 | 45 | r | [534] |
| $^{12}C$ | Si | 70? | | | | r | [347] |
| $^{12}C$ | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}C$ | $^{32}S$ | 2100 | | 1250 | 51 | em | [355] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1550 | 60 | | [328] |
| $^{12}C$ | $^{40}Ca$ | 83 | | 1510 | 60 | | [329] |
| $^{12}C$ | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}C$ | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}C$ | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 30 | | 2185 | 140 | | [329] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1815 | 100 | | [328] |
| $^{12}C$ | $^{54}Fe$ | 83 | | 1776 | 100 | | [329] |
| $^{12}C$ | [illegible] | [illegible] | | [illegible] | [illegible] | | [328] |
| $^{12}C$ | $^{56}Fe$ | 83 | | 1791 | 150 | | [329] |
| $^{12}C$ | $^{57}Fe$ | [illegible] | | 2206 | 160 | | [329] |
| $^{12}C$ | $^{57}Fe$ | [illegible] | | 1820 | [illegible] | | [illegible] |
| $^{12}C$ | $^{57}Fe$ | 83 | | 1867 | 100 | | [329] |
| $^{12}C$ | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}C$ | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}C$ | Cu | 25 | 1.7 | 2350 | 360 | z,r | [171] |
| $^{12}C$ | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}C$ | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}C$ | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}C$ | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}C$ | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}C$ | Zn | 200 | | 1747 | 110 | | [329] |

r = read data from plots

z =sum of different reactions

# How to find the good stuff

## We are in a stage of quality control...

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{12}$C | 9.33 | | 1465 | 70 | | [168] |
| $^{12}$C | $^{12}$C | 9.33 | | 1444 | 50 | | [430, 329] |
| $^{12}$C | $^{12}$C | 24.42 | | 1170 | $^{+170}_{-100}$ | z | [472] |
| $^{12}$C | $^{12}$C | 28.7 | | 1240 | 200 | z | [364] |
| $^{12}$C | $^{12}$C | 30 | | 1315 | 40 | | [430, 328] |
| $^{12}$C | $^{12}$C | 30 | | 1316 | 40 | | [329] |
| $^{12}$C | C | 32.5 | 6.5 | 1209 | 32 | x | [487] |
| $^{12}$C | $^{12}$C | 33.1 | | 1331 | 75 | | [563] |
| $^{12}$C | C | 40.3 | 13.9 | 1159 | 11 | x | [487] |
| $^{12}$C | $^{12}$C | 40.7 | | 1173 | 56 | | [223] |
| $^{12}$C | C | 46.1 | 7.2 | 1125 | 15 | x,d | [487] |
| $^{12}$C | C | 56.4 | 18.8 | 1076 | 22 | x | [487] |
| $^{12}$C | C | 69.9 | 31.6 | 1039 | 9 | x | [487] |
| $^{12}$C | C | 76.4 | 12.2 | 1013 | 12 | x,d | [487] |
| $^{12}$C | $^{12}$C | 83 | | 957 | 39 | | [564] |
| $^{12}$C | $^{12}$C | 83 | | 960 | 30 | | [430, 328] |
| $^{12}$C | $^{12}$C | 83 | | 965 | 30 | | [329] |
| $^{12}$C | C | 86.3 | 22.8 | 998 | 13 | x | [487] |
| $^{12}$C | C | 98.8 | 43.5 | 962 | 10 | x | [487] |
| $^{12}$C | C | 118.4 | 20.2 | 919 | 11 | x,d | [487] |
| $^{12}$C | C | 121.1 | 64.9 | 910 | 5 | x | [487] |
| $^{12}$C | C | 139.8 | 40.1 | 870 | 5 | x,d | [487] |
| $^{12}$C | C | 157.4 | 20.1 | 831 | 9 | x,d | [487] |
| $^{12}$C | C | 195.5 | 33.2 | 797 | 13 | x | [487] |
| $^{12}$C | $^{12}$C | 200 | | 864 | 45 | | [329] |
| $^{12}$C | C | 224.5 | 25.0 | 789 | 12 | x | [487] |
| $^{12}$C | $^{12}$C | 250 | | 873 | 60 | | [329] |
| $^{12}$C | C | 250.8 | 50.3 | 782 | 9 | x | [487] |
| $^{12}$C | C | 274.7 | 25.3 | 776 | 12 | x,d | [487] |

| Proj | Target | Energy MeV/A | ΔE MeV/A | $\sigma_R$ mb | $\Delta\sigma_R$ mb | Notes | Ref |
|---|---|---|---|---|---|---|---|
| $^{12}$C | $^{28}$Si | 5.42 | | 1440 | 60 | s | [557] |
| $^{12}$C | Si | 27 | 6 | 1700 | 40 | r | [534] |
| $^{12}$C | Si | 39 | 5 | 1555 | 45 | r | [534] |
| $^{12}$C | Si | 70? | | | | r | [347] |
| $^{12}$C | Si | 3658 | | 1130 | 80 | | [38] |
| $^{12}$C | $^{32}$S | 2100 | | 1250 | 51 | em | [355] |
| $^{12}$C | $^{40}$Ca | 83 | | 1550 | 60 | | [328] |
| $^{12}$C | $^{40}$Ca | 83 | | 1510 | 60 | | [329] |
| $^{12}$C | Fe | 200 | | 1648 | 110 | | [329] |
| $^{12}$C | Fe | 250 | | 1595 | 120 | | [329] |
| $^{12}$C | Fe | 300 | | 1575 | 110 | | [329] |
| $^{12}$C | $^{54}$Fe | 30 | | 2185 | 140 | | [329] |
| $^{12}$C | $^{54}$Fe | 83 | | 1815 | 100 | | [328] |
| $^{12}$C | $^{54}$Fe | 83 | | 1776 | 100 | | [329] |
| $^{12}$C | [illegible] | 83 | | [illegible] | [illegible] | | [328] |
| $^{12}$C | $^{56}$Fe | 83 | | 1791 | 150 | | [329] |
| $^{12}$C | $^{57}$Fe | 30 | | 2296 | [illegible] | | [329] |
| $^{12}$C | [illegible] | 83 | | [illegible] | [illegible] | | [328] |
| $^{12}$C | $^{57}$Fe | 83 | | 1867 | 100 | | [329] |
| $^{12}$C | Cu | 29.78 | | 2404 | 99 | | [451] |
| $^{12}$C | Cu | 15 | 2.5 | 2200 | 350 | z,r | [171] |
| $^{12}$C | Cu | 25 | 1.7 | 2350 | 350 | z,r | [171] |
| $^{12}$C | Cu | 35 | | 1750 | 250 | z,r | [171] |
| $^{12}$C | Cu | 45 | 1.0 | 1650 | 250 | z,r | [171] |
| $^{12}$C | Cu | 2100 | | 1730 | 36 | em | [355] |
| $^{12}$C | Cu | 3658 | | 1700 | 90 | | [38] |
| $^{12}$C | Cu | 3700 | | 2700 | 200 | e | [185] |
| $^{12}$C | Cu | 4500 | | 2000 | 100 | e | [31] |
| $^{12}$C | Zn | 200 | | 1747 | 110 | | [329] |

Do we need more columns?
(Laboratory, Exp. method)

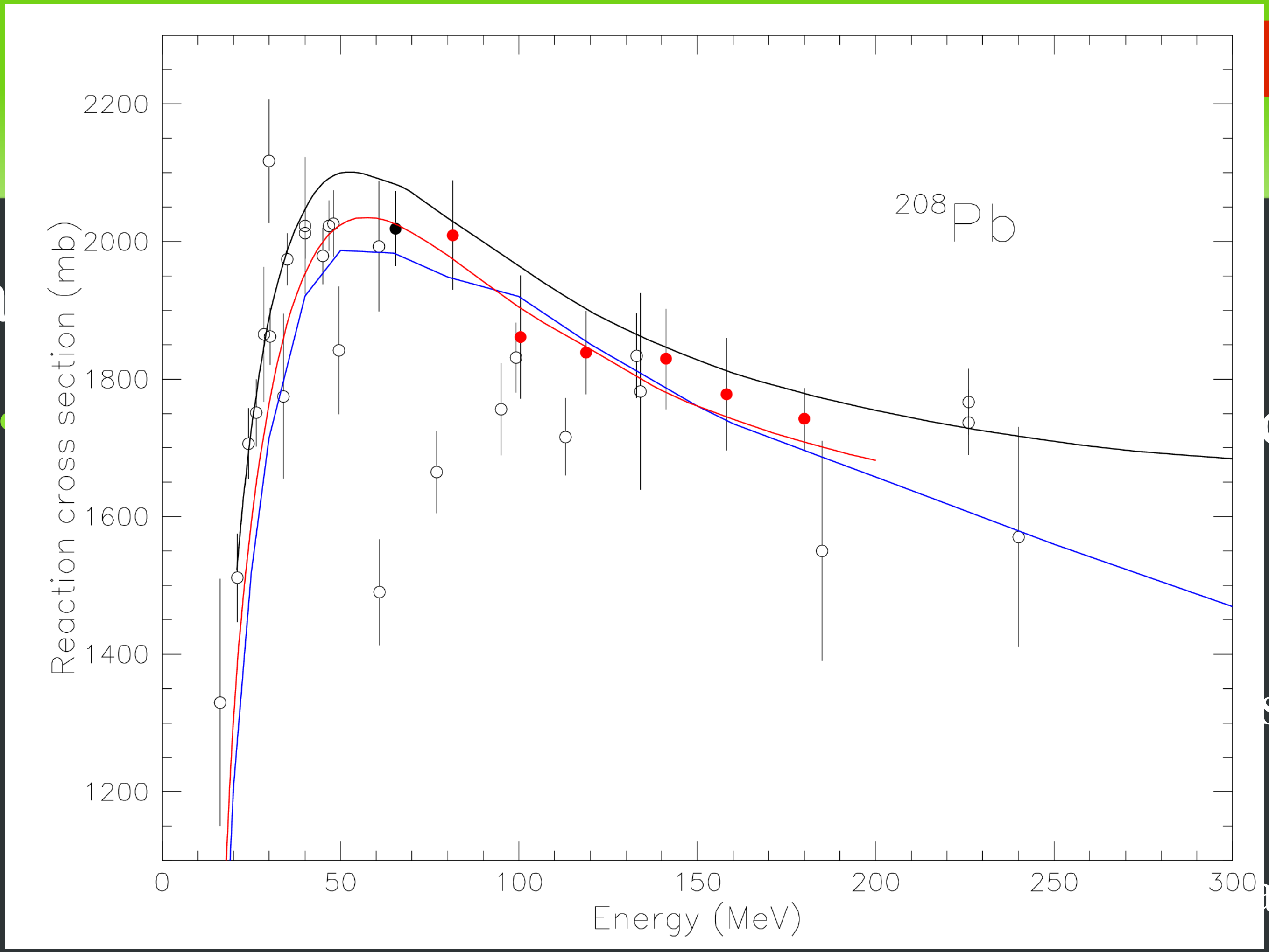
# How to find the good stuff

- Quality check of all references –> decrease the list
  - Which kind of experimental methods should be included?
    - Direct measurements
    - Summed or integrated partial cross sections
    - Emulsion and solid state track detectors
    - Model dependent derivations from other variables
  - Will set threshold based on quality of experimental method, not on quality of result
  - Maybe good reasons why some data are forgotten...?

EFNUDAT

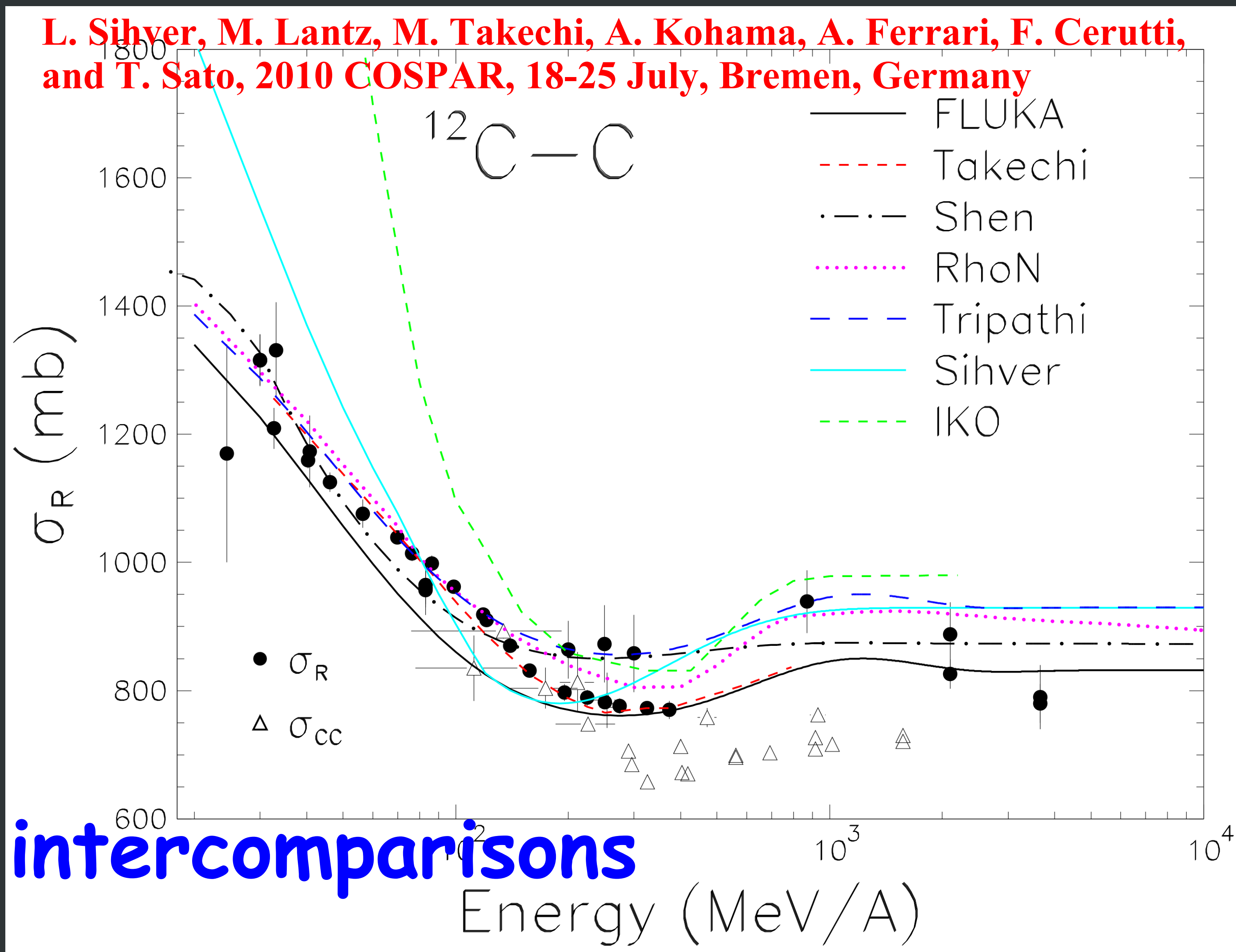
# Ho… …tuff

- Qua… …the list
  - …d be
  - …s
  - …ariables




  - **Will set threshold based on quality of experimental method, not on quality of result**
  - Maybe good reasons why some data are forgotten...?

# Positive effects from the addiction



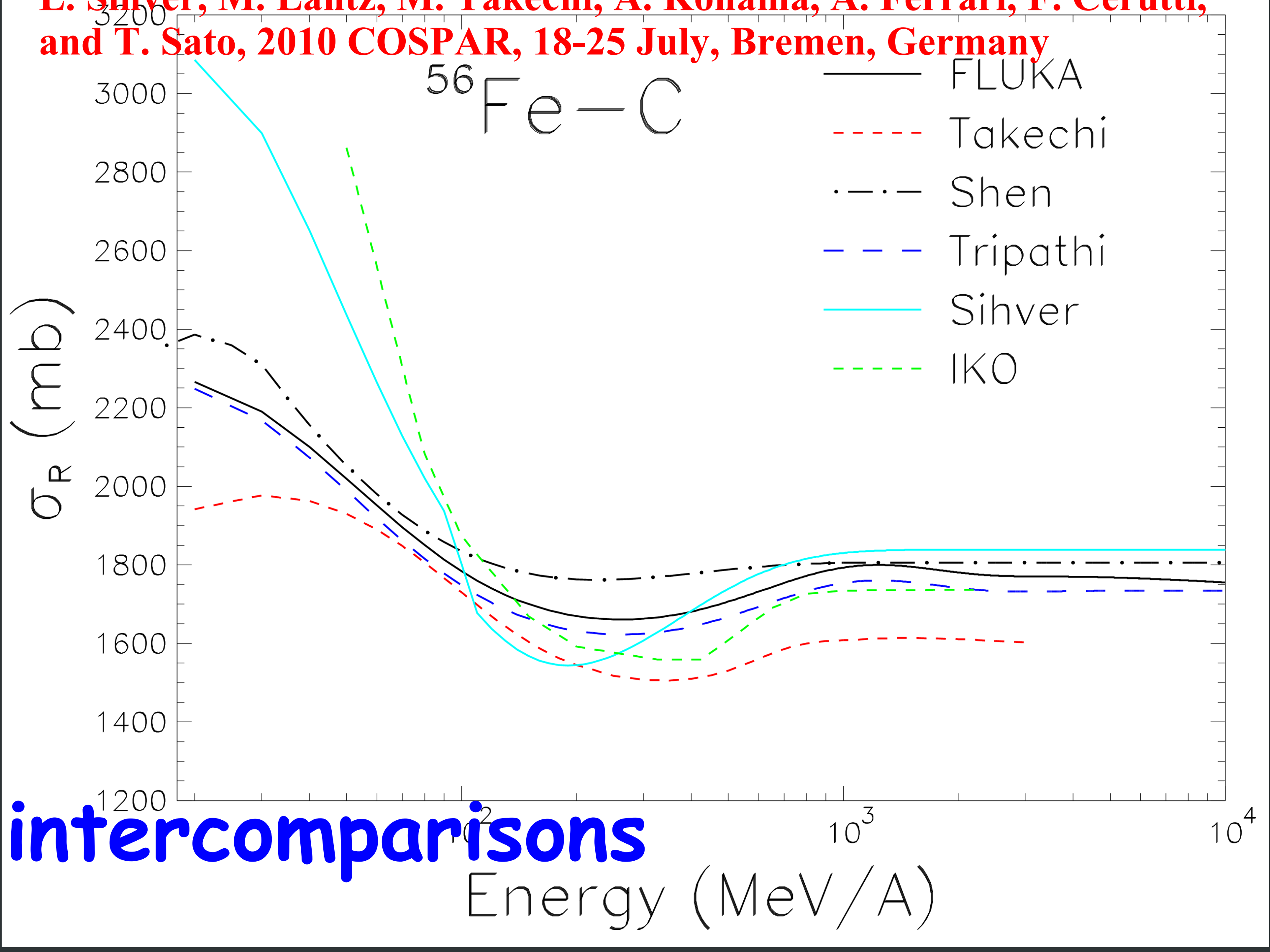

L. Sihver, M. Lantz, M. Takechi, A. Kohama, A. Ferrari, F. Cerutti, and T. Sato, 2010 COSPAR, 18-25 July, Bremen, Germany

**Code intercomparisons**

EFNUDAT

# Positive effects from the addiction

L. Sihver, M. Lantz, M. Takechi, A. Kohama, A. Ferrari, F. Cerutti, and T. Sato, 2010 COSPAR, 18-25 July, Bremen, Germany

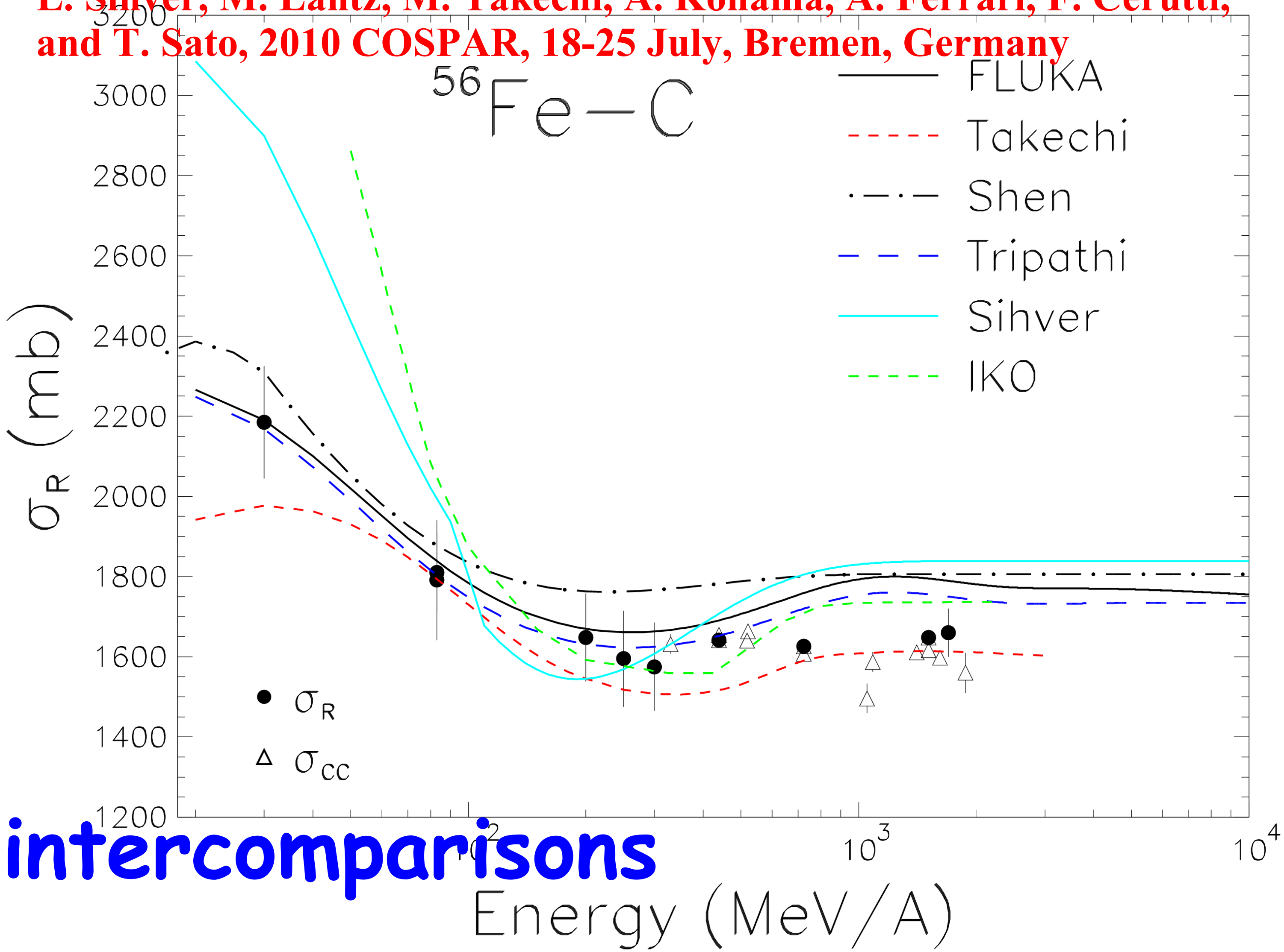



## Code intercomparisons

EFNUDAT

# Positive effects from the addiction

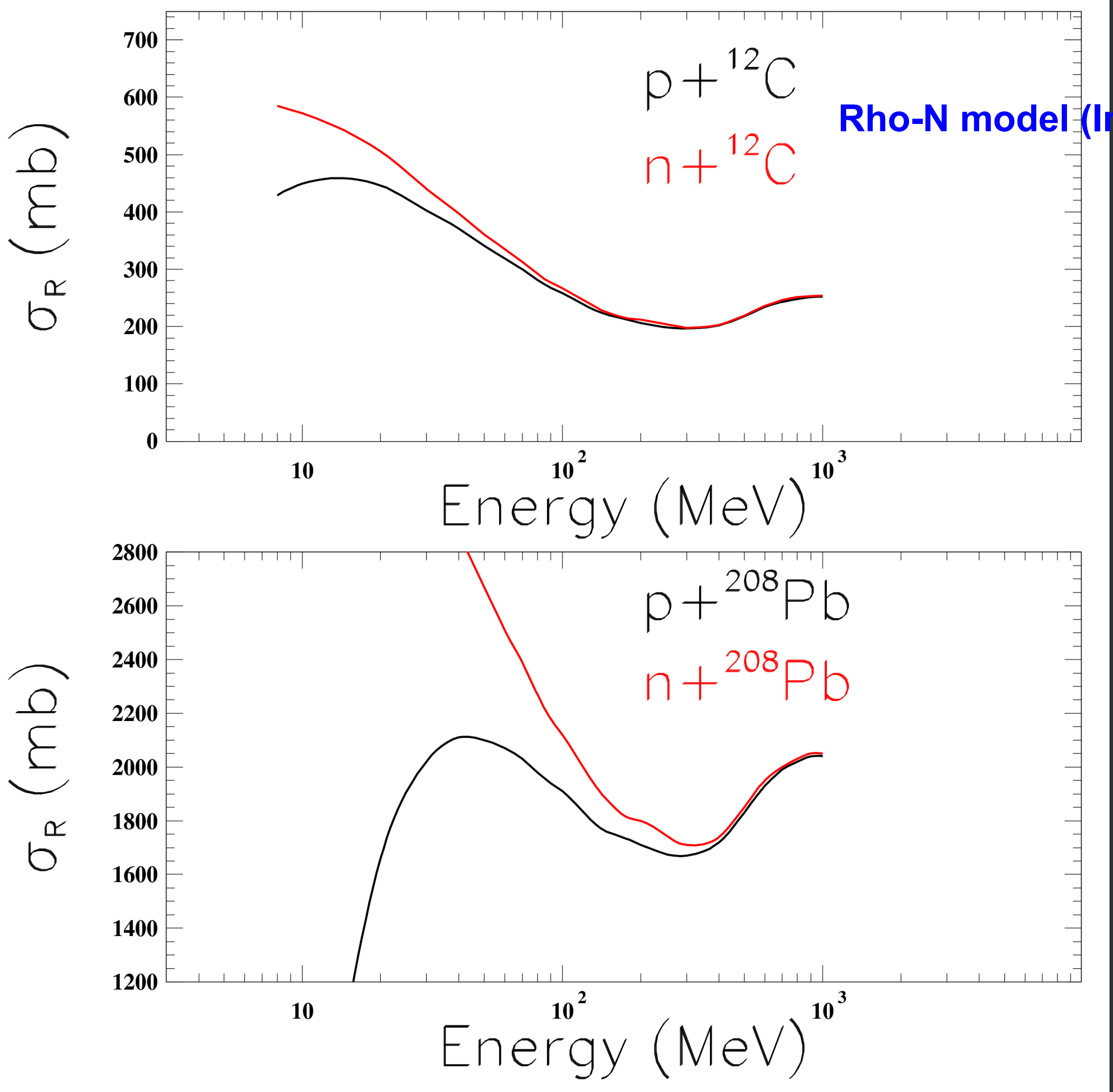
L. Sihver, M. Lantz, M. Takechi, A. Kohama, A. Ferrari, F. Cerutti, and T. Sato, 2010 COSPAR, 18-25 July, Bremen, Germany




**Code intercomparisons**

# Positive effects from the addiction

## Motivate new neutron measurements?

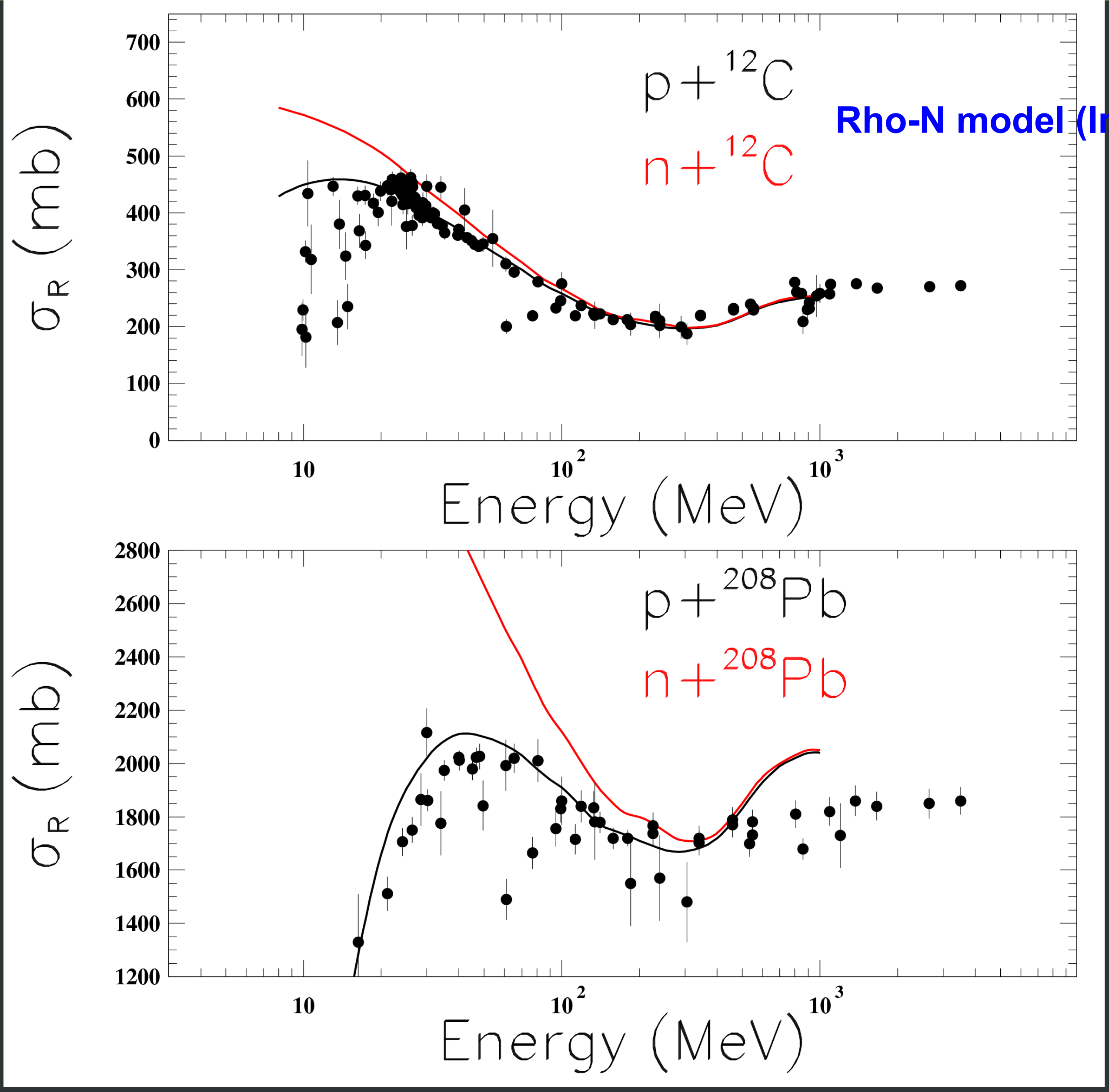



Rho-N model (Ingemarsson & Lantz (2005)

# Positive effects from the addiction

## Motivate new neutron measurements?

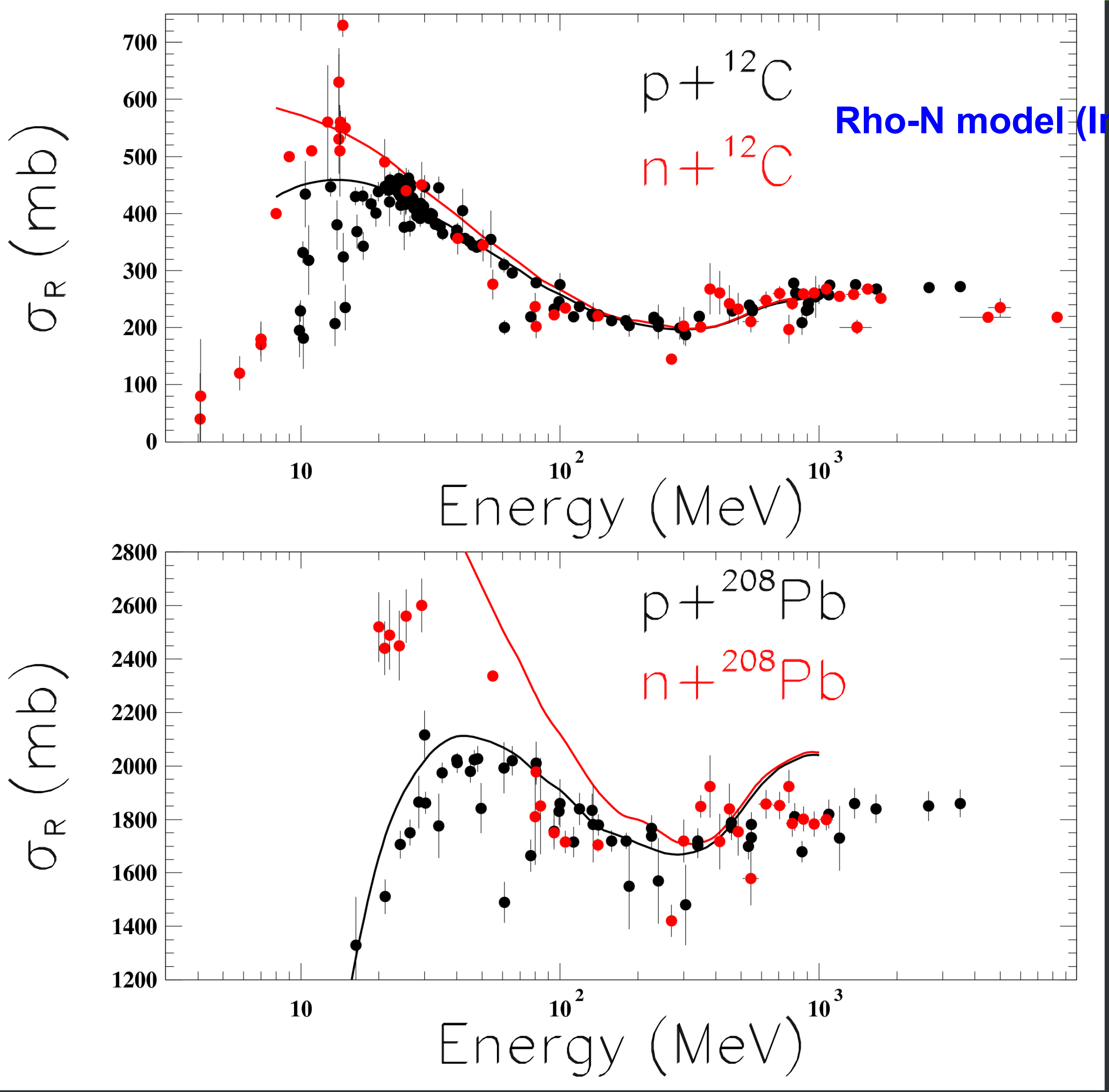
Rho-N model (Ingemarsson & Lantz (2005)



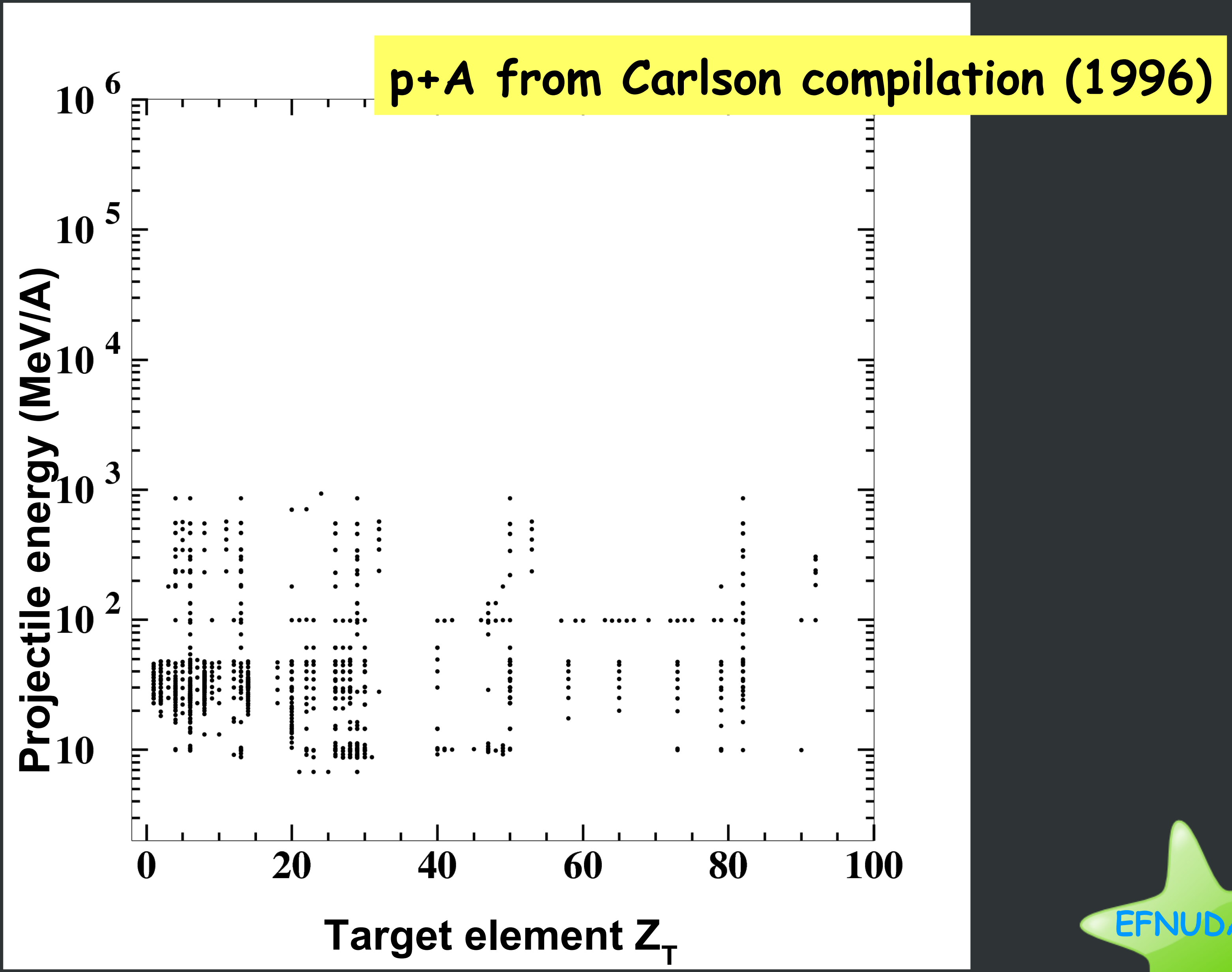
# Positive effects from the addiction

## Motivate new neutron measurements?

Rho-N model (Ingemarsson & Lantz (2005)

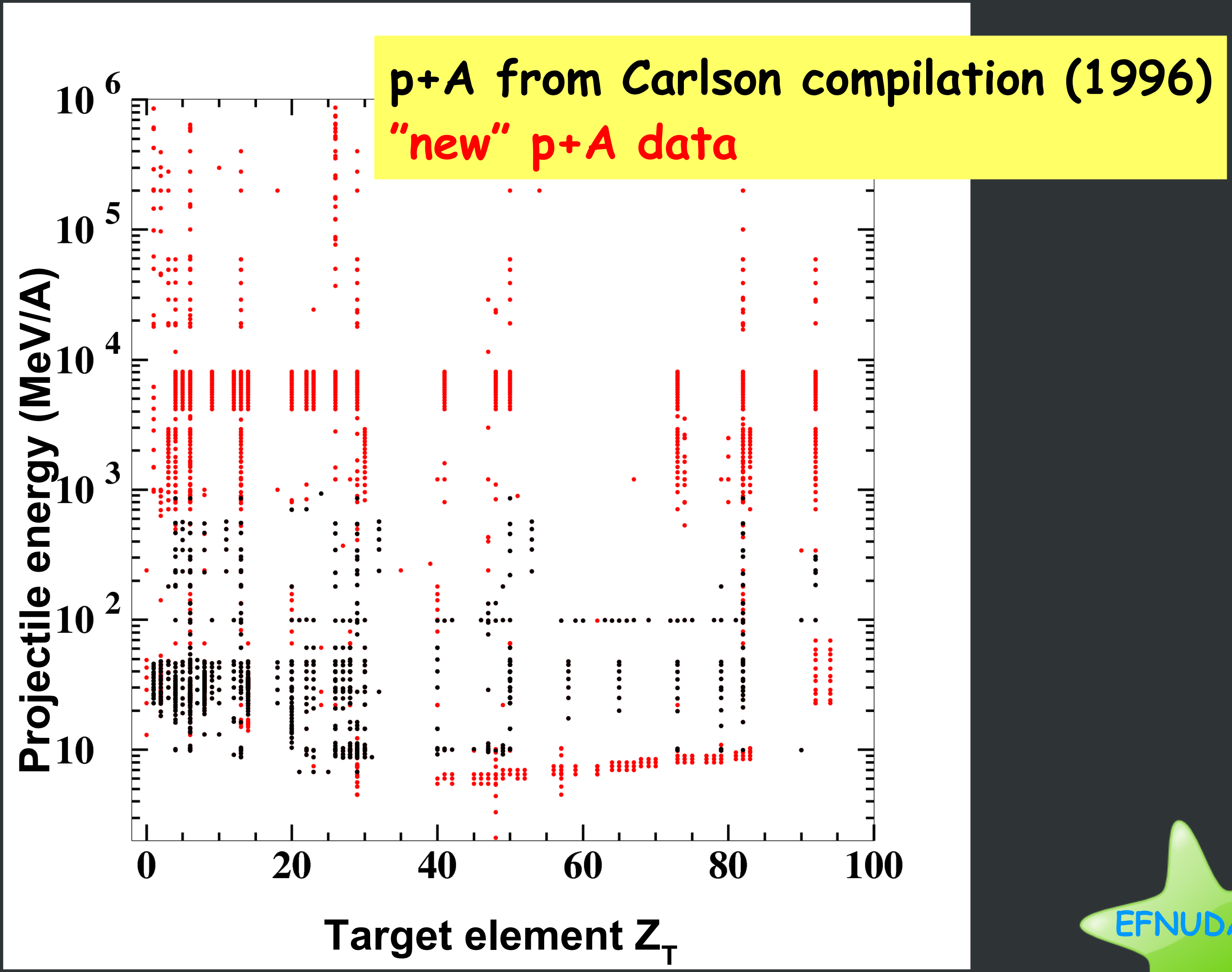


# Other effects from the addiction



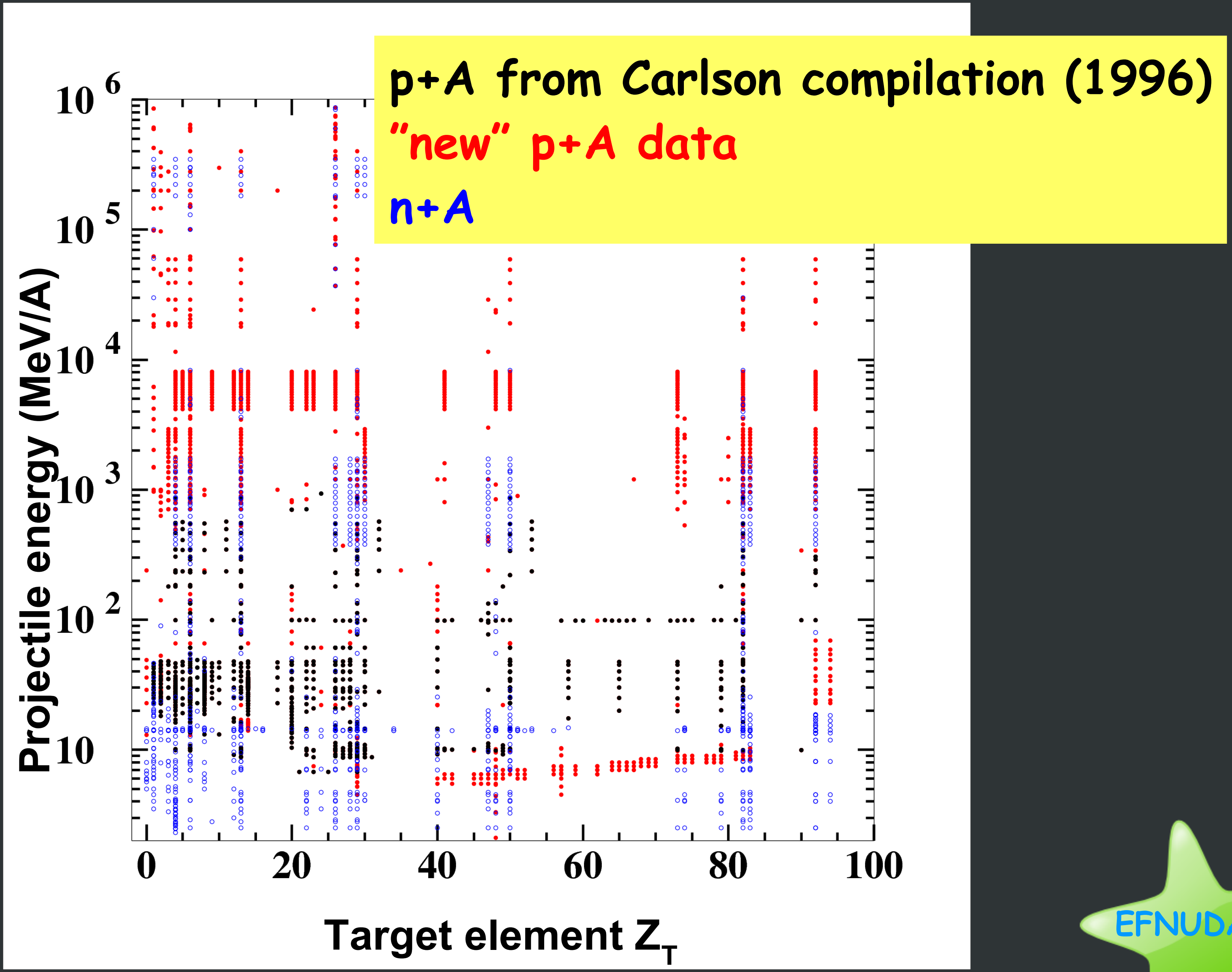

EFNUDAT

# Other effects from the addiction

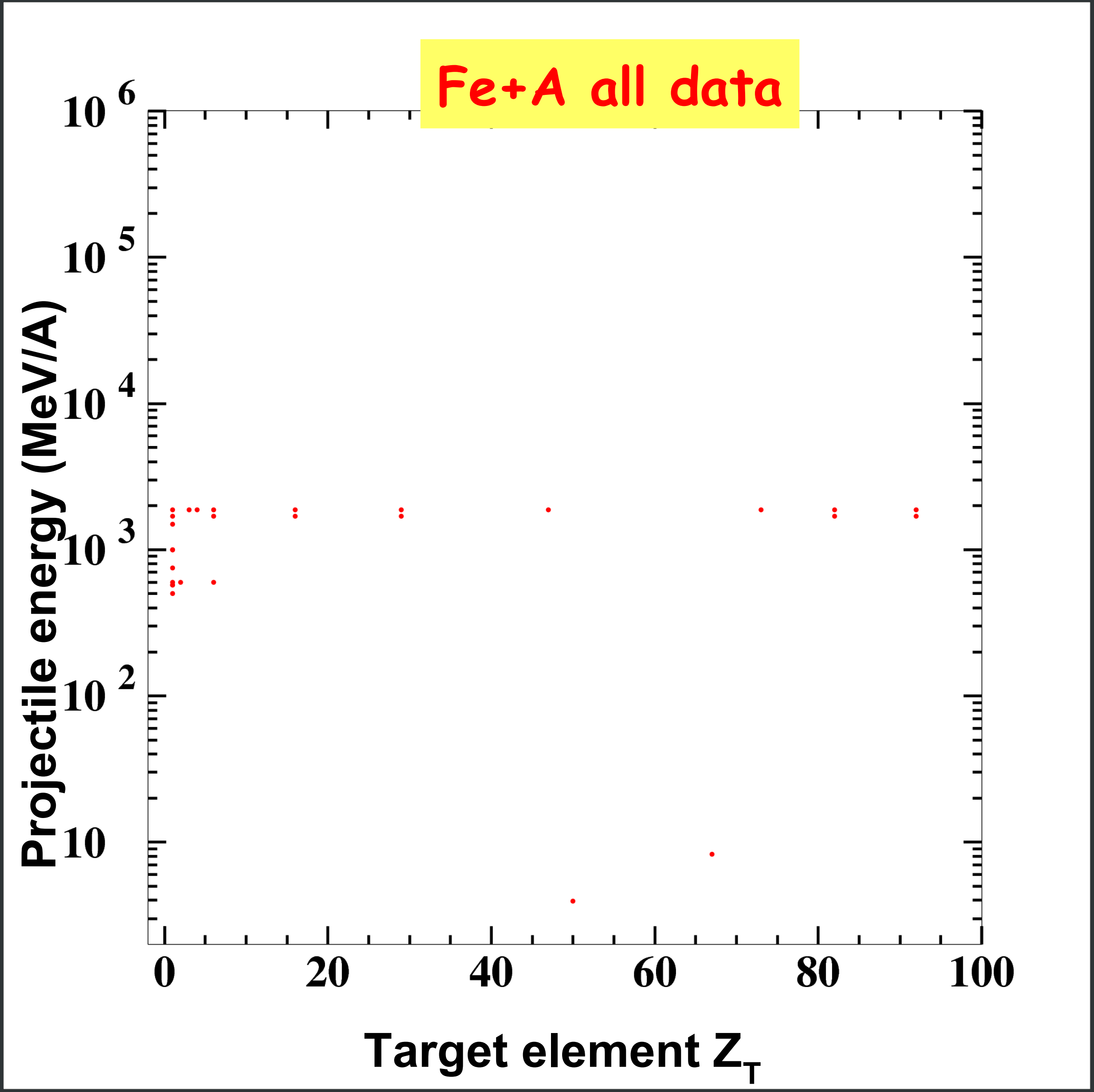



EFNUDAT

# Other effects from the addiction

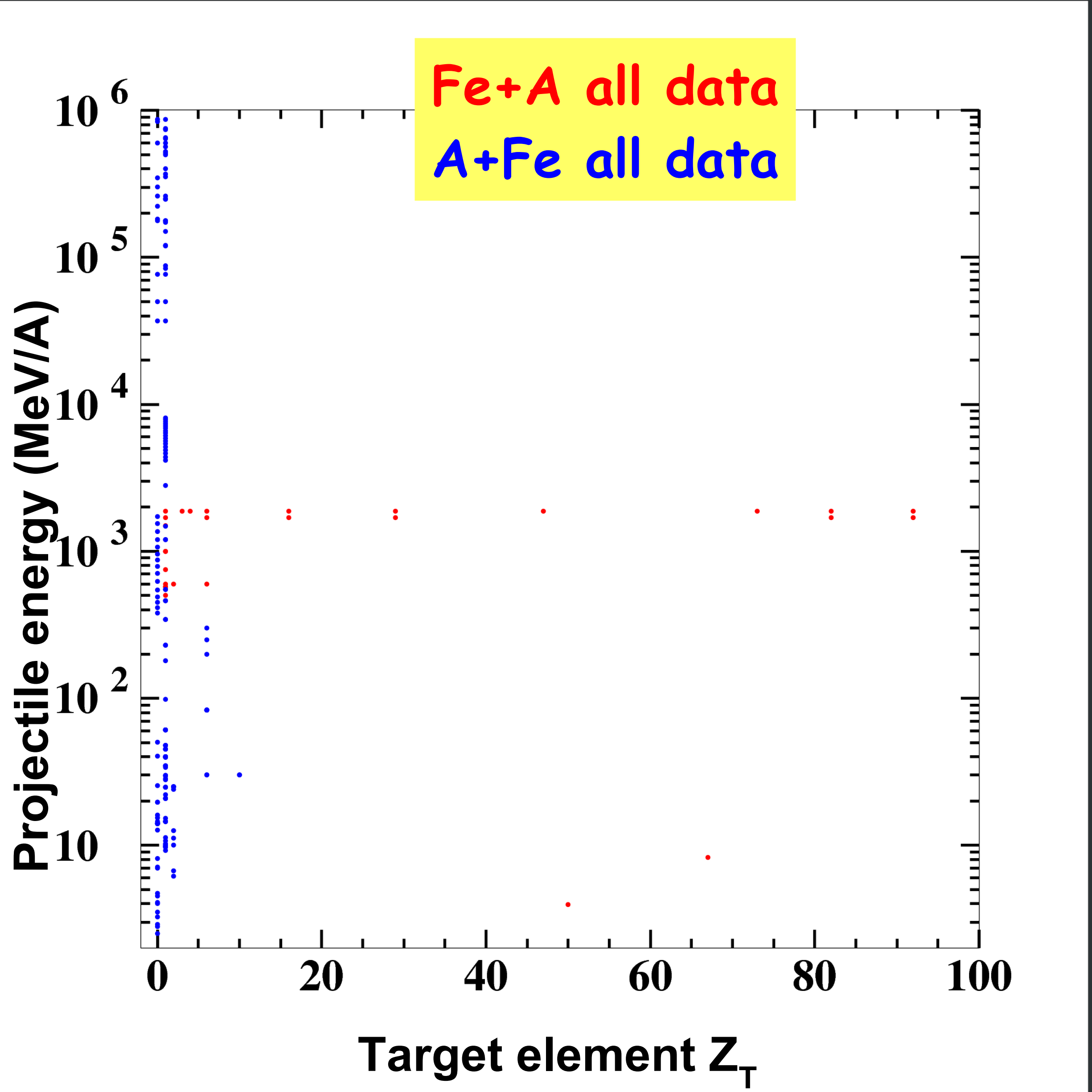


# Other effects from the addiction



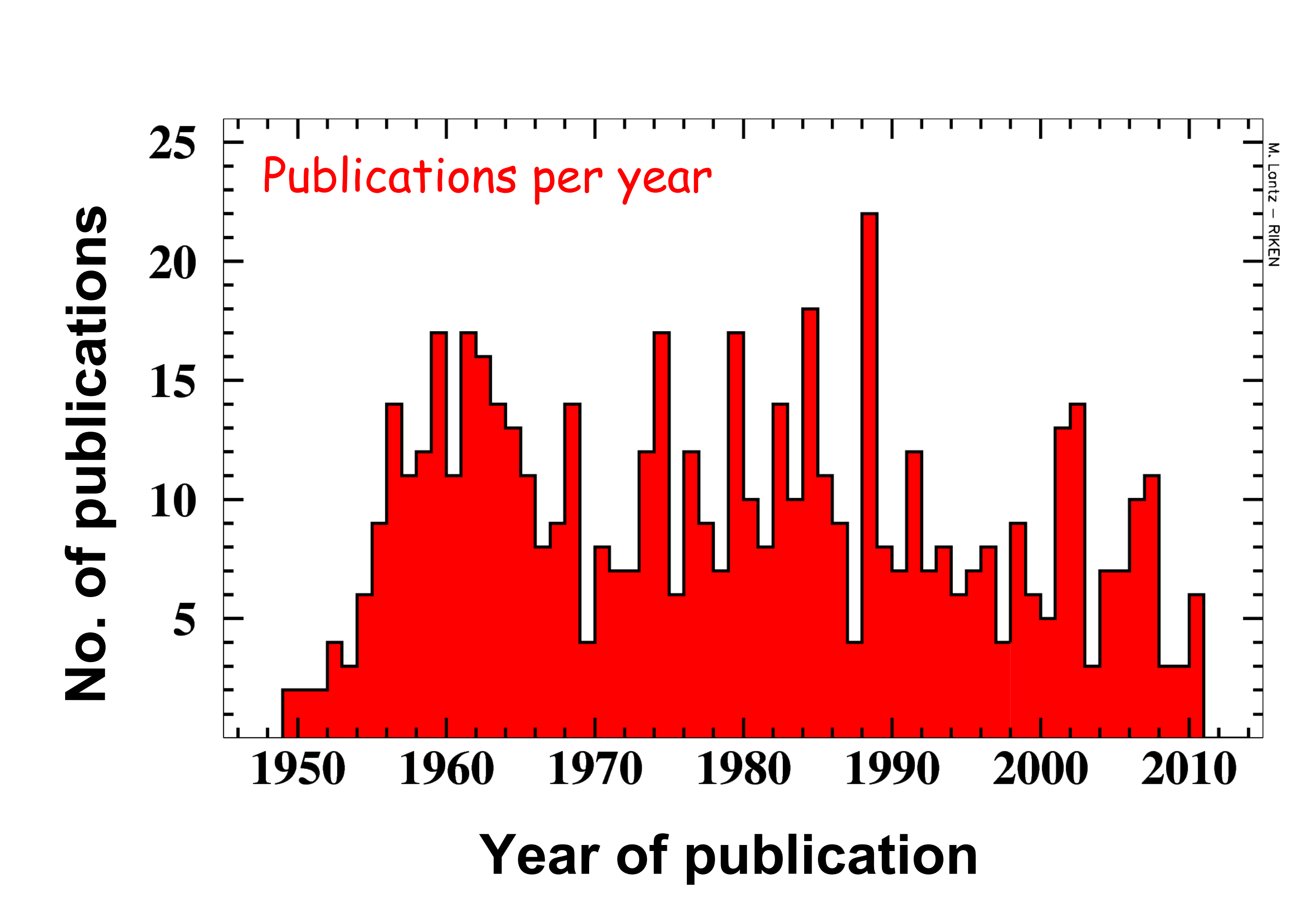

EFNUDAT

# Other effects from the addiction



# Other effects from the addiction

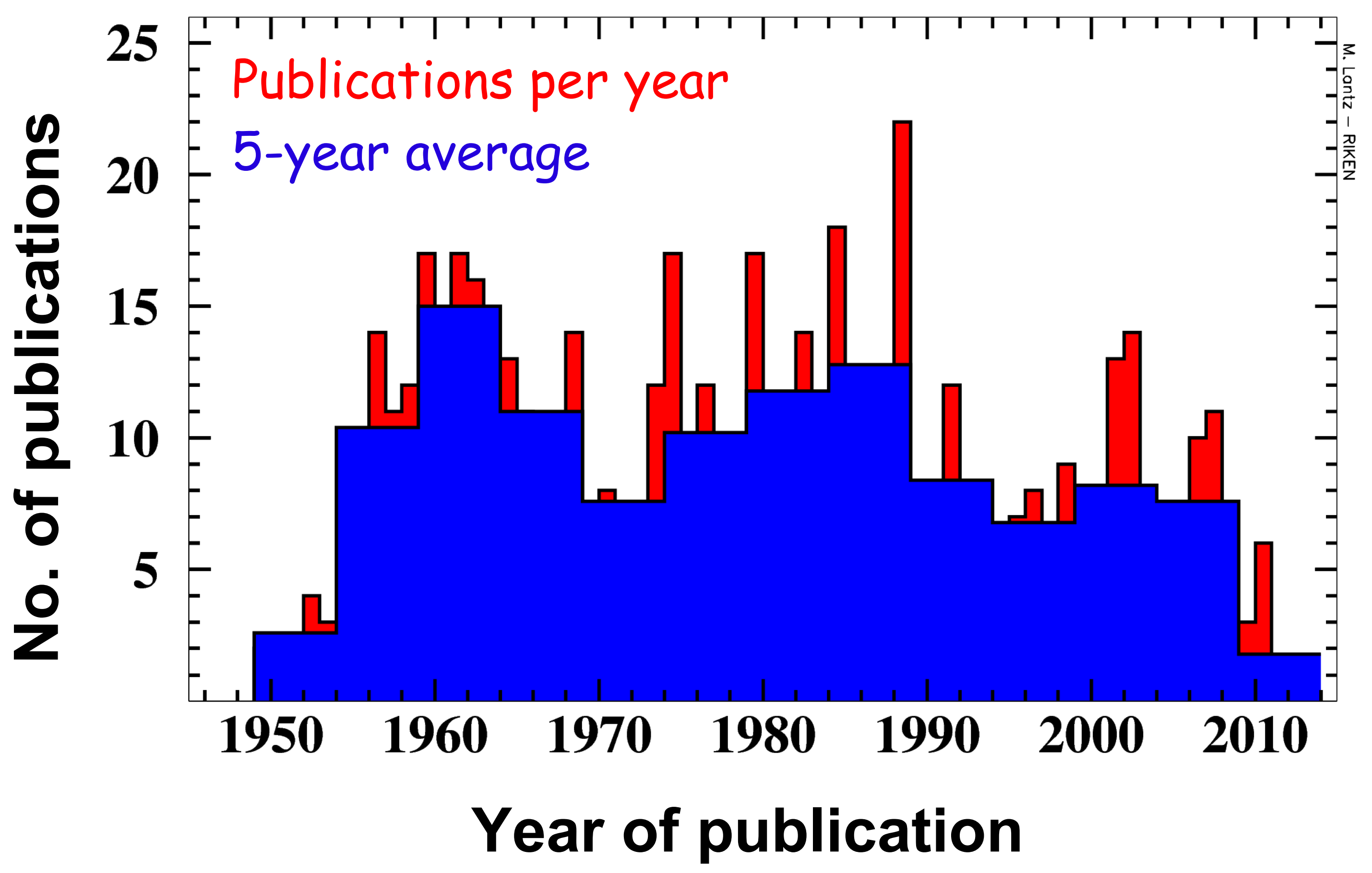
## Science history, or sociology?




EFNUDAT

# Other effects from the addiction

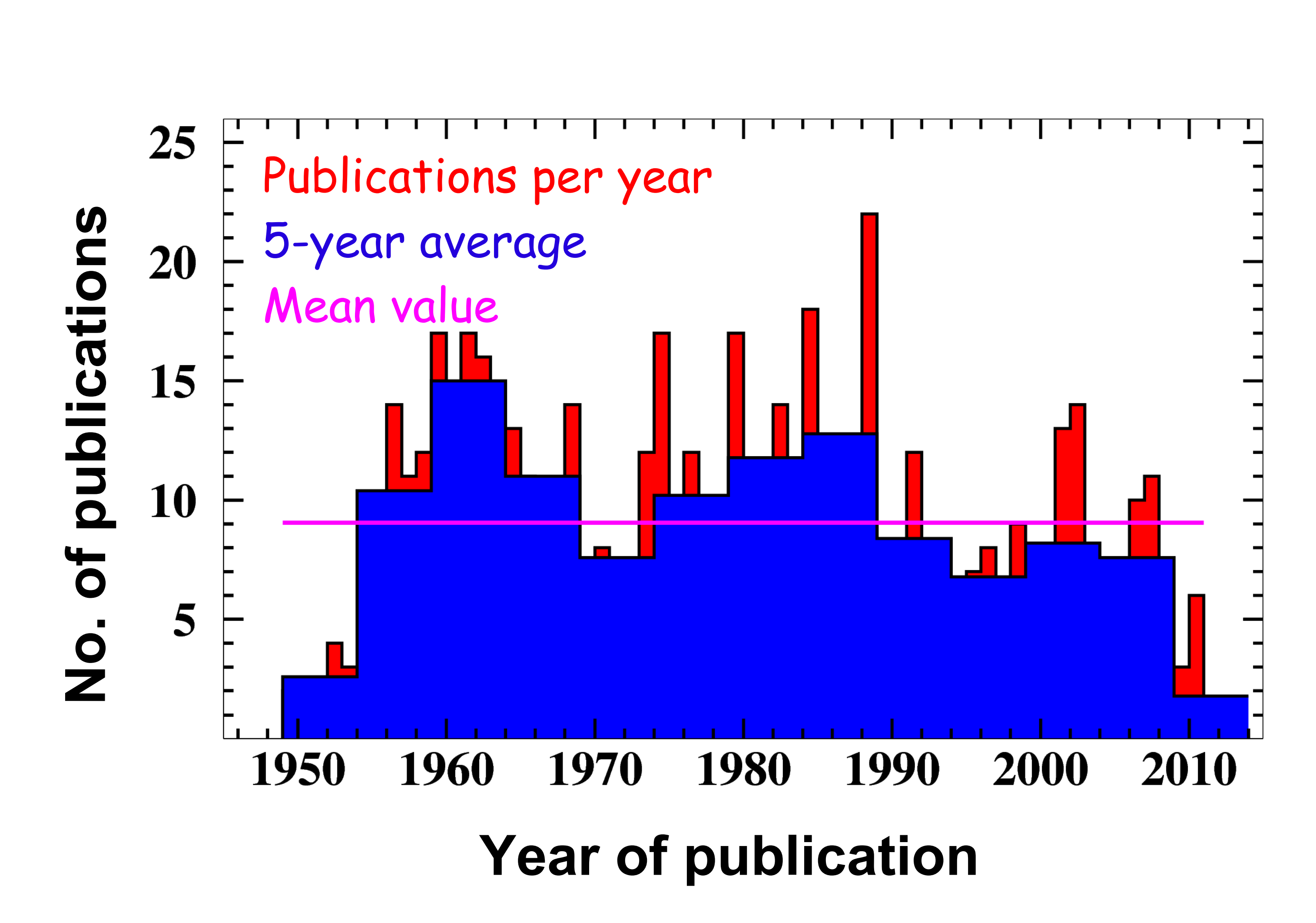
## Science history, or sociology?




EFNUDAT

# Other effects from the addiction

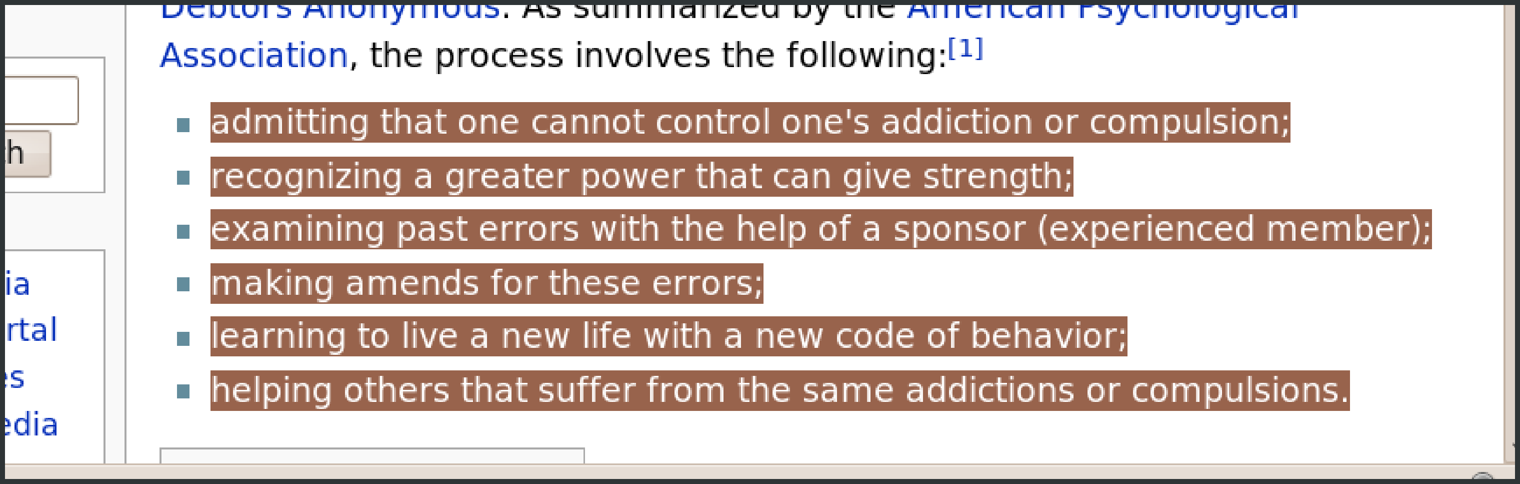
## Science history, or sociology?




EFNUDAT

# A call for help

- Still looking for more data, do **You** have any?
- How would **You**, as potential user of the compilation, prefer it to look like?
- Please contact us if you have any feedback, data, or comments: Mattias.Lantz@fysast.uu.se


Debtors Anonymous. As summarized by the American Psychological Association, the process involves the following:[1]

- admitting that one cannot control one's addiction or compulsion;
- recognizing a greater power that can give strength;
- examining past errors with the help of a sponsor (experienced member);
- making amends for these errors;
- learning to live a new life with a new code of behavior;
- helping others that suffer from the same addictions or compulsions.

EFNUDAT

# Thank you for your attention!


- Acknowledgements for valuable feedback, help, and inspiration
  - Akihisa Kohama, Maya Takechi, Hiroyoshi Sakurai – RIKEN
  - Mitsunori Fukuda, Daisuke Nishimura – Osaka University
  - Takayuki Yamaguchi – Saitama University
  - Chen Li – Lanzhou
  - Richard F. Carlson – Redlands University
  - Alfredo Ferrari – CERN
  - Grzegorz Kaminski - JINR
- Lantz' work partly funded by JSPS 日本学術振興会 Japan Society for the Promotion of Science